

What can we expect in WY'14?

Klaus Wolter

NOAA-Earth System Research Lab & University of Colorado at Boulder-CDC

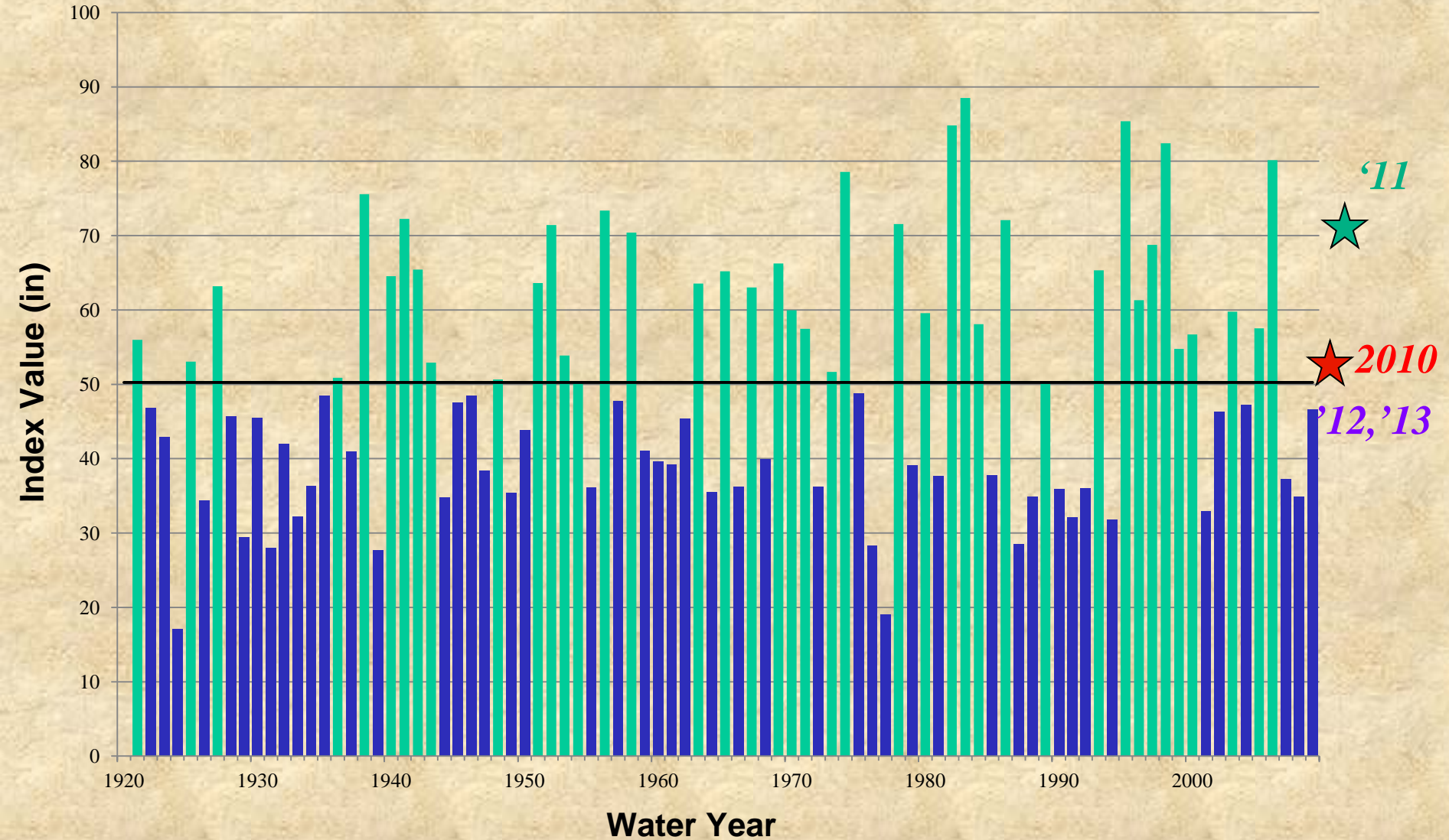
klaus.wolter@noaa.gov

Kudos to Jeanine Jones for support

- **‘Postmortem’ 2012-3**
- **ENSO (*and MJO*): current situation and outlook**
- **Official CPC forecasts**
- **Other factors influencing CA wet season precipitation**
- **2nd experimental forecast for CA**
- **Colorado River musings and next two weeks overall**
- **Executive Summary**



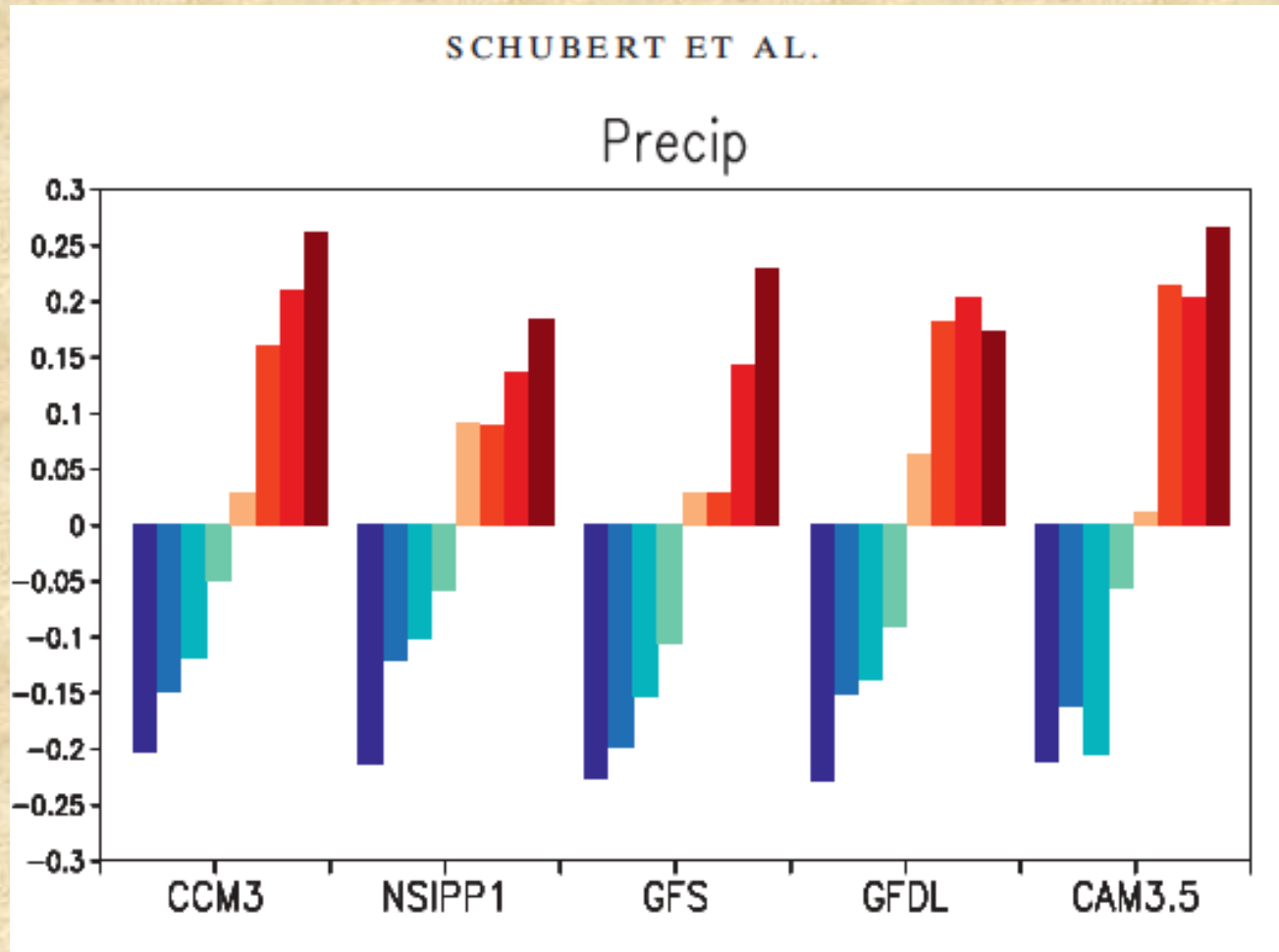
Northern Sierra 8 Station Precipitation Index



2012&2013 brought close to 45” each – 5 out of 7 last years dry!

© Maurice Roos

<PDO-AMO> was a good predictor last year

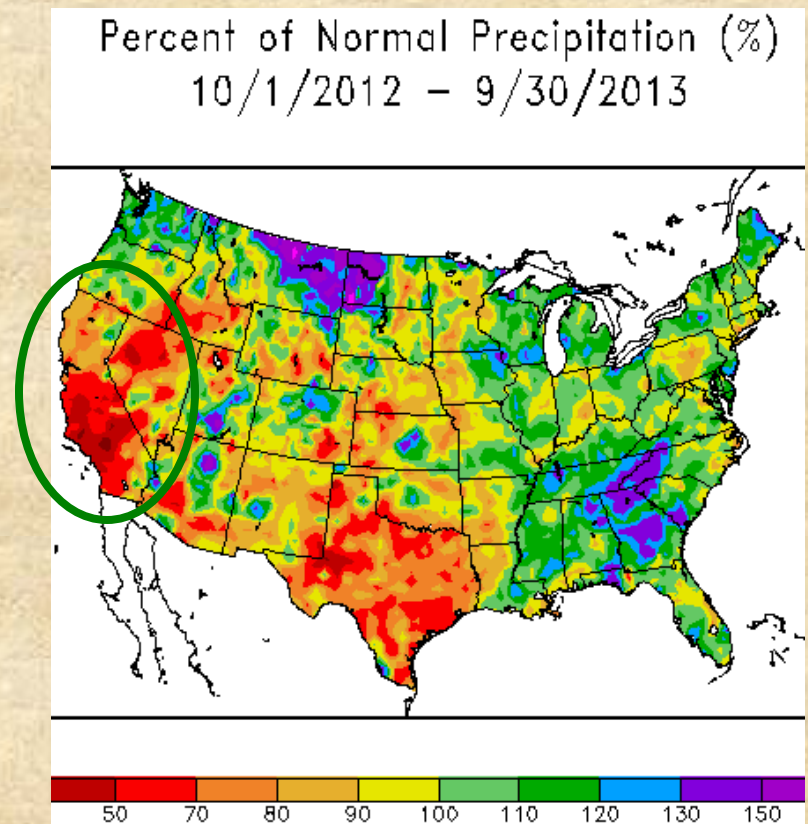
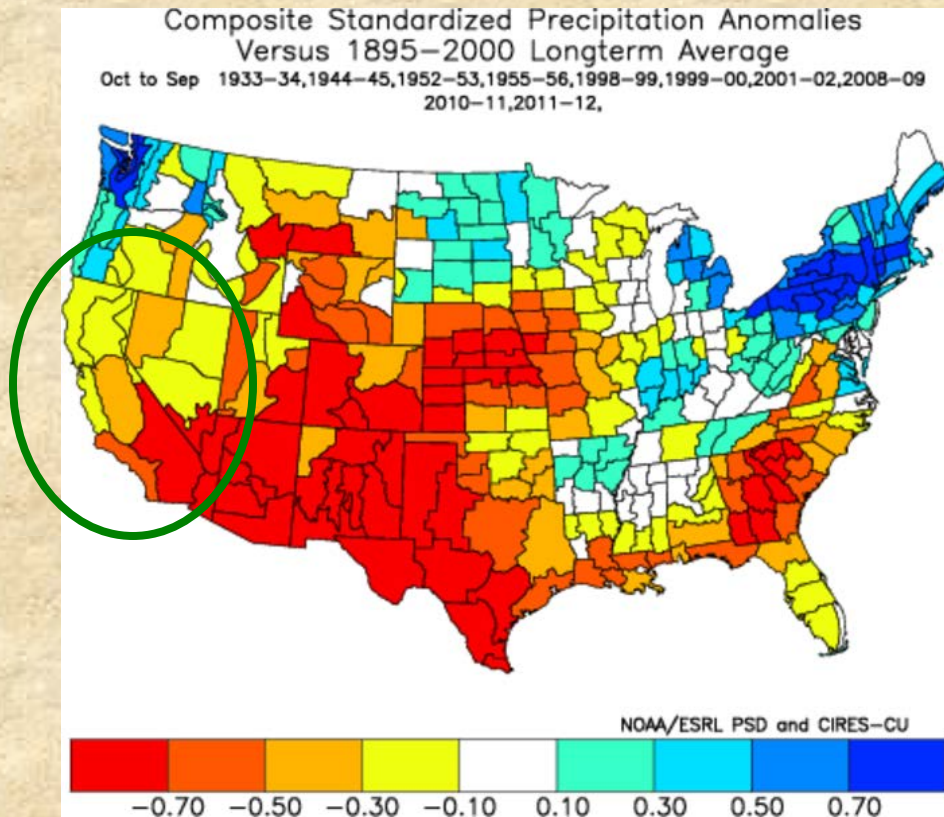


*Schubert et al.
(J. Climate,
2009)*

*In five different
GCMs, a cold
Pacific combines
with a warm North
Atlantic to produce
most pervasive
drought conditions
in continental U.S.*

PcAw PcAn PcAc PnAw PnAc PwAw PwAn PwAc

What happened in WY'13?

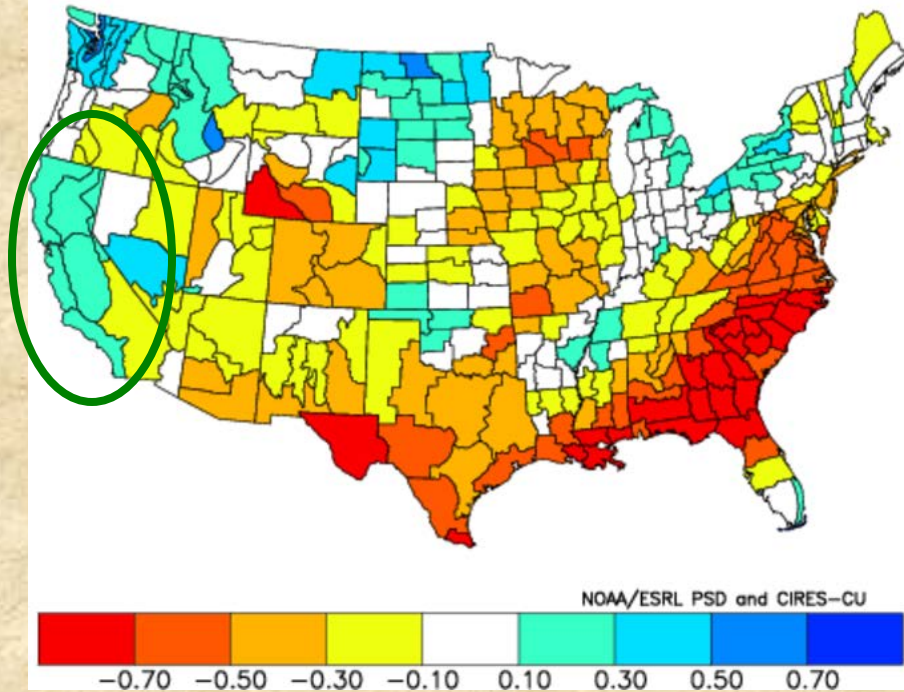


2012-13 ended up quite dry, particularly in Southern California. This was reasonably well anticipated by my PDO-AMO composites (seasonal breakdown to follow), not so well by the experimental forecasts.

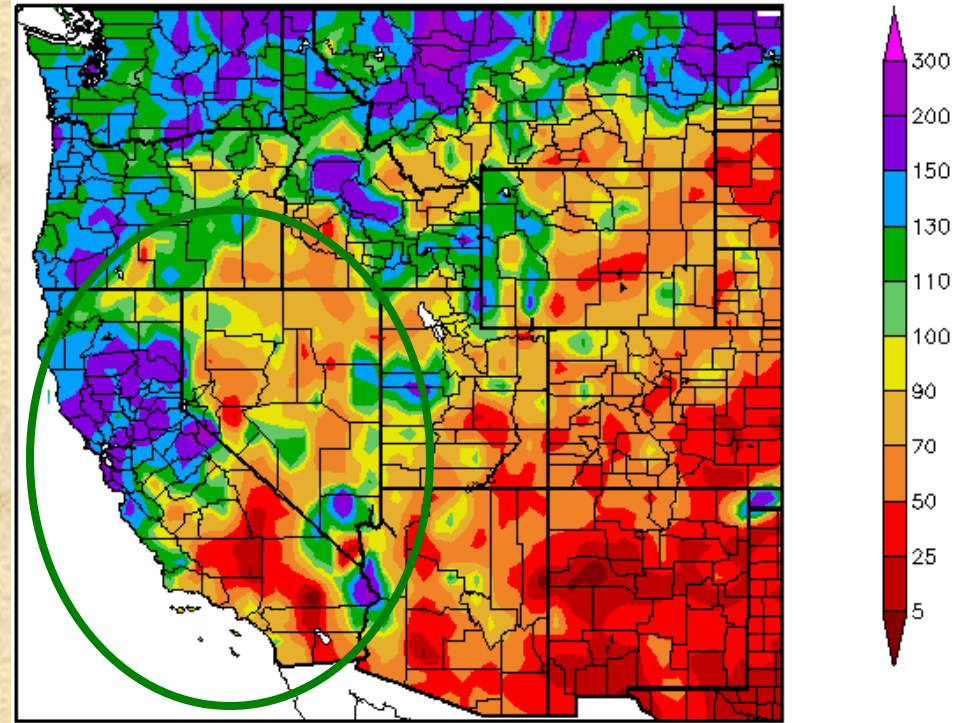
Note that the 10 years picked here were based on the lowest decile of a century of a PDO minus AMO index (2012 was the lowest index value on record for June-September '12). This will be revisited in 2013 where conditions have weakened somewhat but are still of the same sign.

What happened in WY'13?

Composite Standardized Precipitation Anomalies
Oct to Dec 1933,1944,1952,1955,1998,1999,2001,2008,2010,2011
Versus 1895–2000 Longterm Average



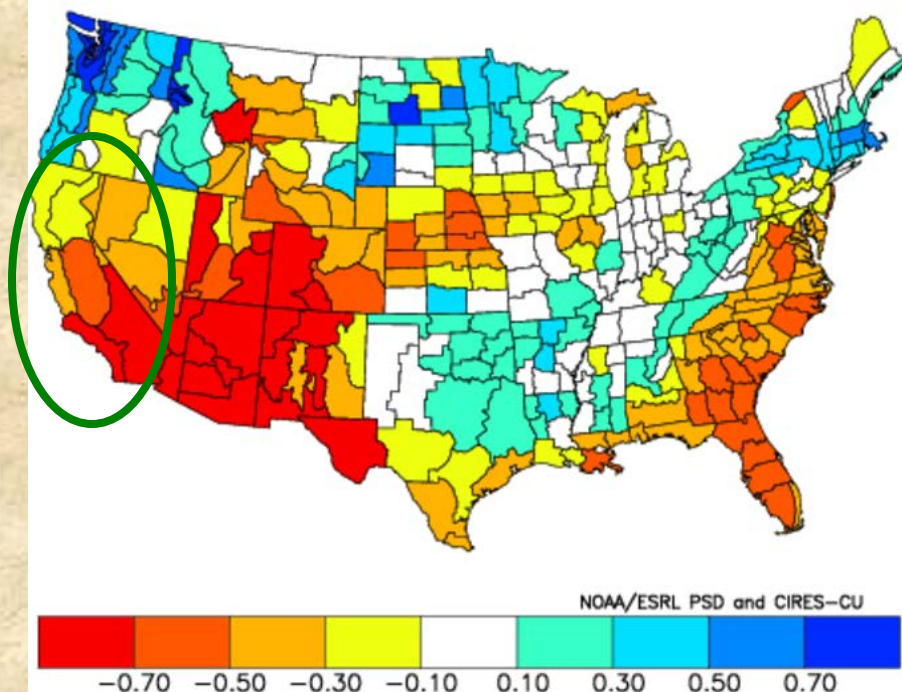
10/1/2012 – 12/31/2012



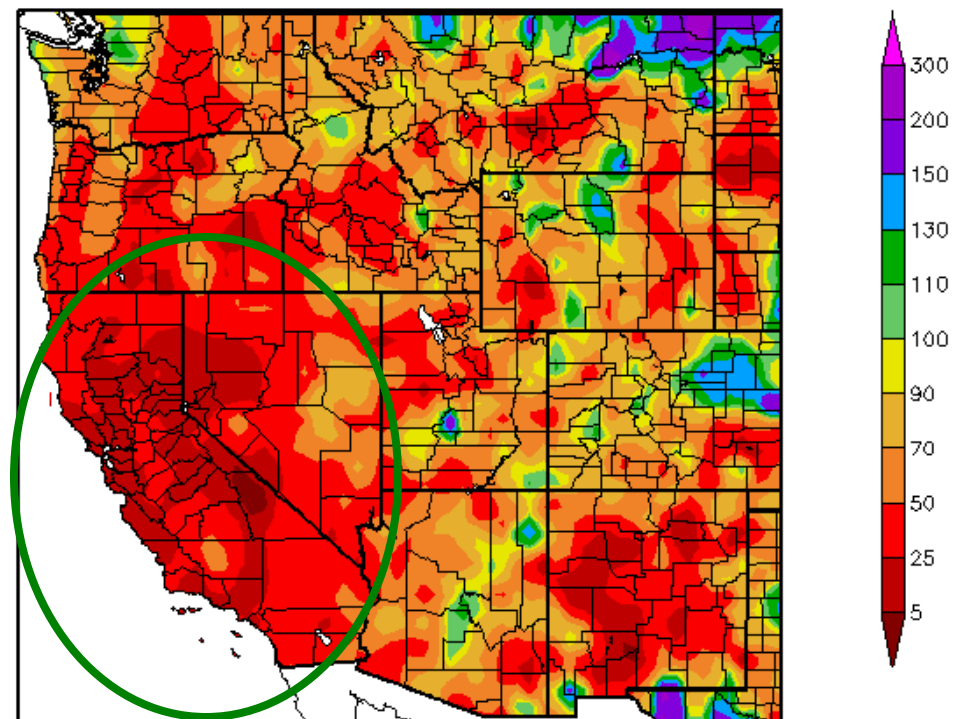
This is the fall season (OND) which ended up fairly wet in northern CA, not in the south. The composites based on the PDO-AMO index worked out very well on a national scale. Of course, the wetness in northern CA was due to AR activity not anticipated by us at last year's meeting just a few weeks before it happened.

What happened in WY'13?

Composite Standardized Precipitation Anomalies
Jan to Mar 1934,1945,1953,1956,1999,2000,2002,2009,2011,2012
Versus 1895–2000 Longterm Average



1/1/2013 – 3/31/2013

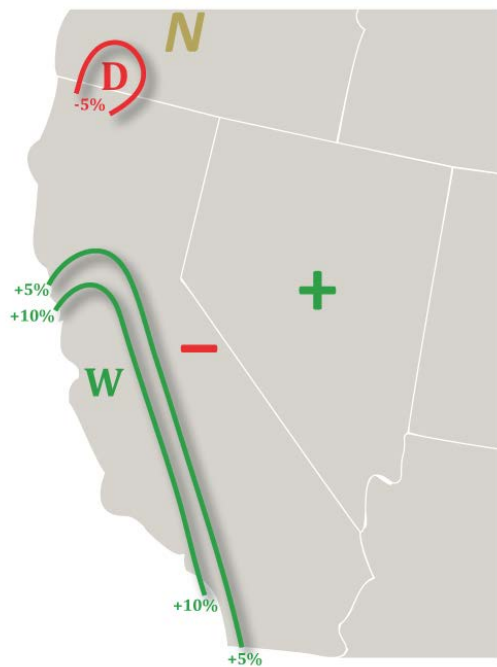


This is the late winter season (JFM) which ended up dry in all of CA. While the skill displayed was not as good in the PNW, the dry forecast for the southwestern U.S., including CA really panned out well.

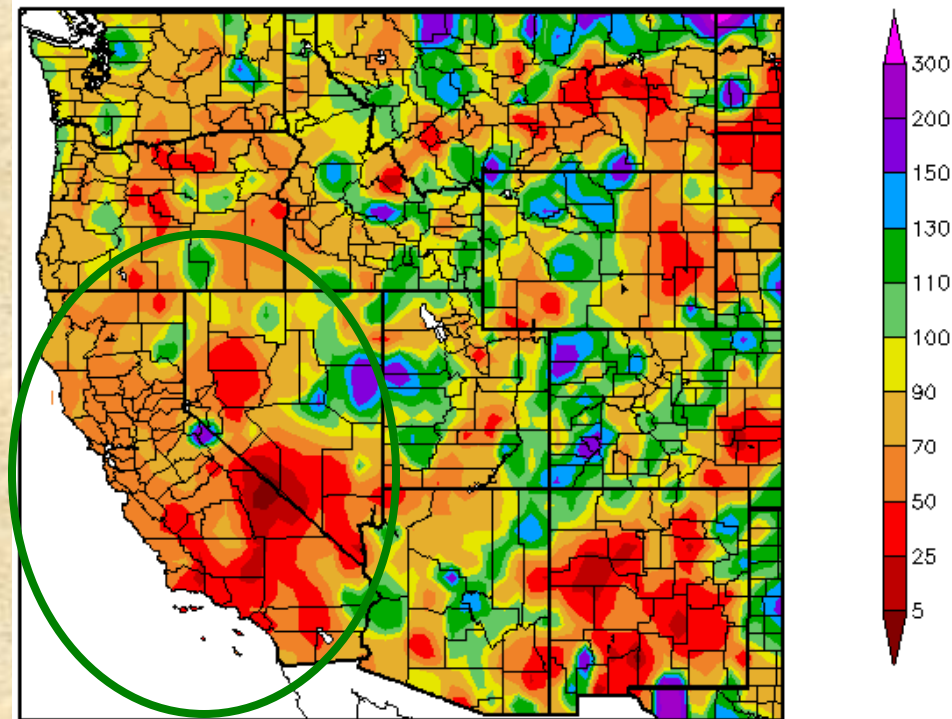
What happened in WY'13?

Experimental PSD Precipitation Forecast Guidance

DEC – FEB 2013 (Issued November 15, 2012)



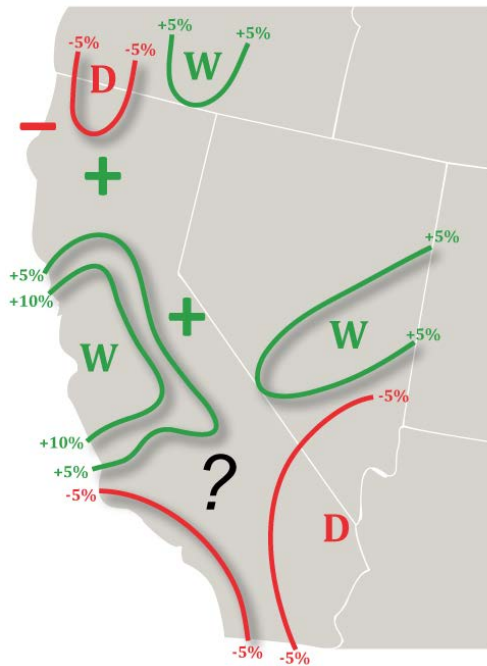
12/1/2012 – 2/28/2013



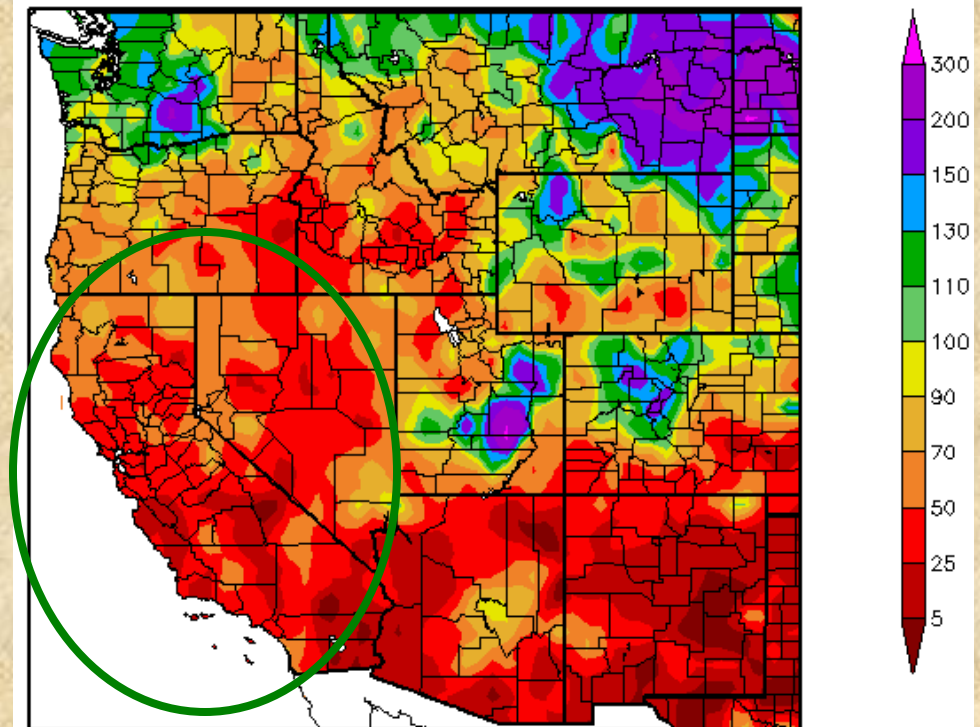
This is the winter season (DJF) which I predicted to be wet along the central and southern coast, but dry over the Sierra and northern interior border with Oregon. To be charitable, I could point out that the dry forecasts verified correctly. Unfortunately, the wet forecasts in CA did not verify so well...

What happened in WY'13?

Experimental PSD Precipitation Forecast Guidance
MAR – MAY 2013 (Issued May 15, 2013)



3/1/2013 – 5/31/2013



This is the spring season (MAM) for which I predicted dry conditions in the south and northwest, but wet from the central coast eastward into NV. Again, the dry forecast verified well, in contrast to my 'irrationally exuberant' wet forecasts...

Lees Ferry Naturalized Runoff in Water Year 2013


& Preliminary Observed value

2013 Runoff: I ran a stepwise regression model that required a priori correlations above 0.35 in 1951-2010 runoff data;

Late fall precipitation and early ENSO behavior were the only two predictors that survived rigorous screening for each of seven scenarios (*all years, and holding out one decade at a time*);

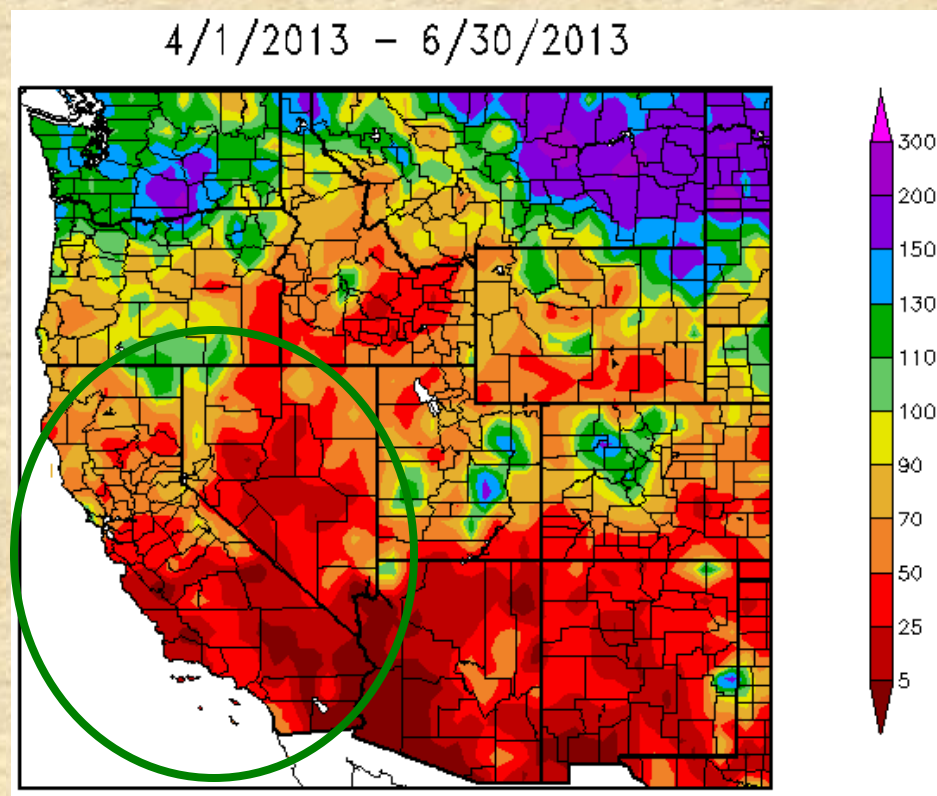
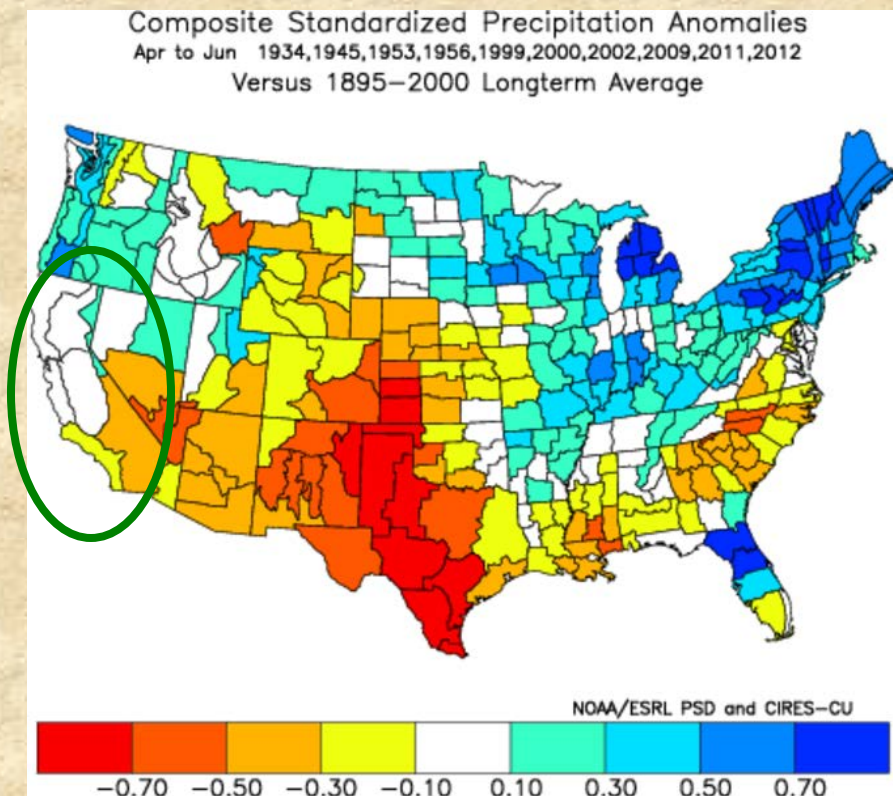
Most forecasts ended up either in the lower tercile of the distribution – I compared the most common tercile category of each forecast in the withheld decades to what was observed to come up with the following 10%/30%/50%/70%/90%ile forecasts versus observed ('naturalized') Water Year runoff [MAf] at Lees Ferry:

	1951-2010	2013	Anomaly	2013-12
10%-ile	9.25	7.73	-1.52	-1.50
30%-ile	11.20	9.75	-1.45	-1.05
50%-ile	13.05	11.03	-2.02	-0.17
70%-ile	16.90	12.97	-3.93	0.54
90%-ile	20.90	16.95	-3.95	0.03
Mean	14.23	10.77	-3.54	-0.84



Observed: 8.31MAf according to Jim Prairie, or 0.2MAf less than year, or the 3rd lowest two-year combination on record!

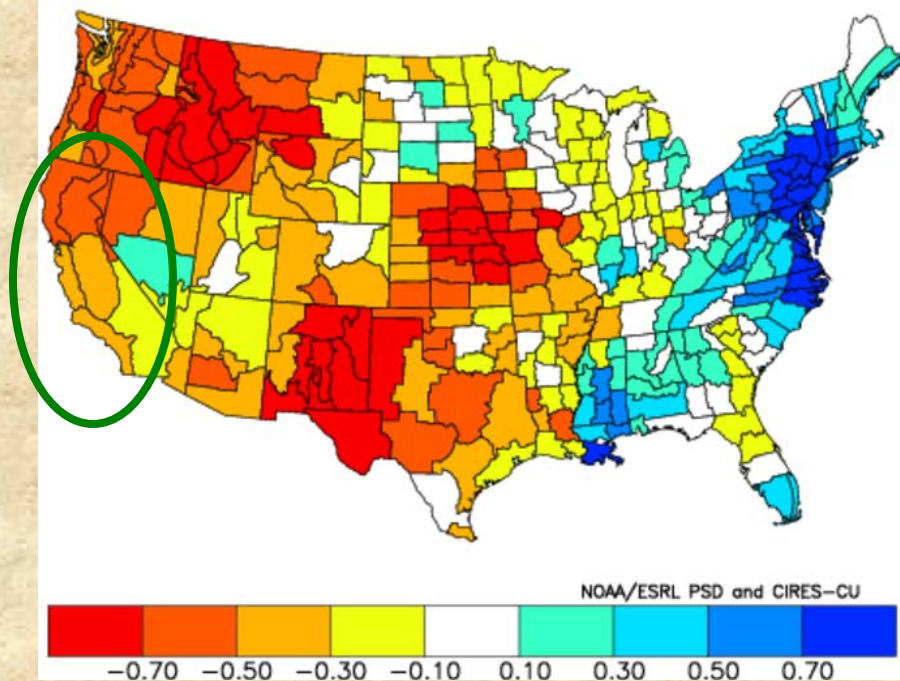
What happened in WY'13?



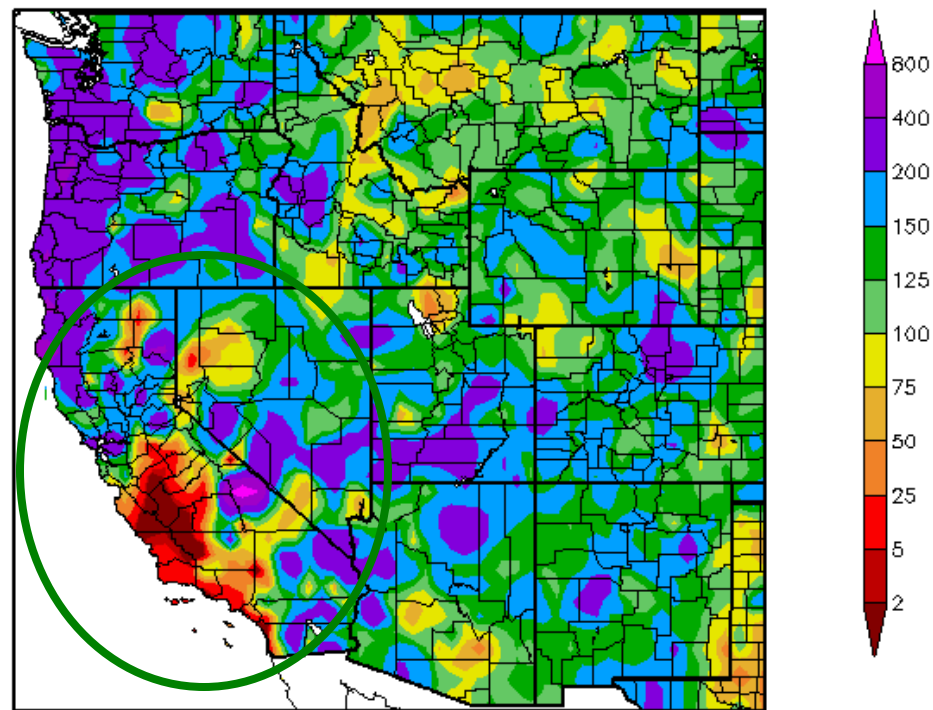
This is the late spring season (AMJ) which ended up dry in most of CA, especially in the south. Note that the cases used here were based on previous summer conditions.

What happened in WY'13?

Composite Standardized Precipitation Anomalies
Jul to Sep 1934,1945,1953,1956,1999,2000,2002,2009,2011,2012
Versus 1895–2000 Longterm Average



7/1/2013 – 9/30/2013



This is the late summer season (JAS) which ended up unusually wet in northern CA, and dry in the south. While a dry summer was anticipated in all of CA, it is fair to say that southern CA got the dry end of the stick all year long!

Note to self: don't use summer time PDO-AMO conditions to predict the subsequent summer!

- Next two weeks appear to favor Pacific Northwest, as is typical for this time of year. Northern CA may benefit from this as well.

Was that the understatement of the year?

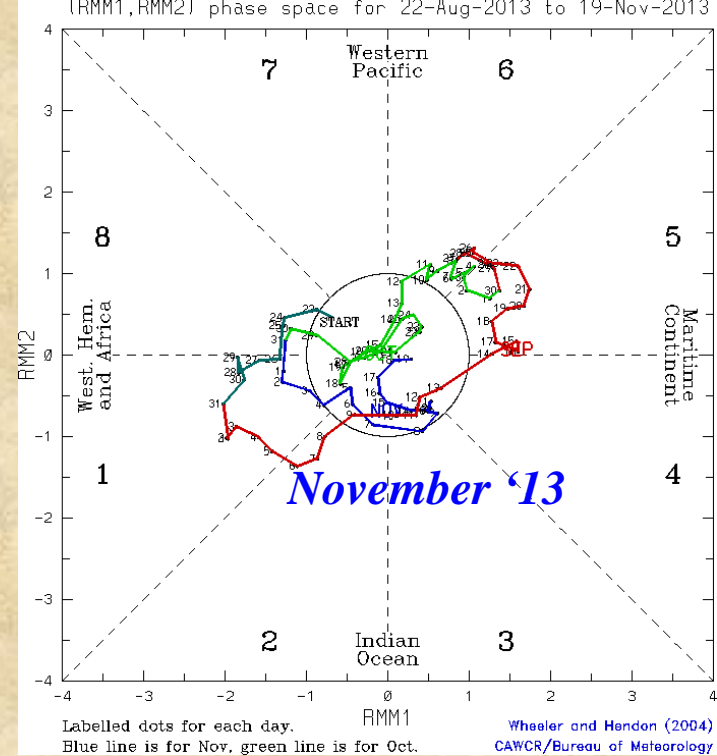
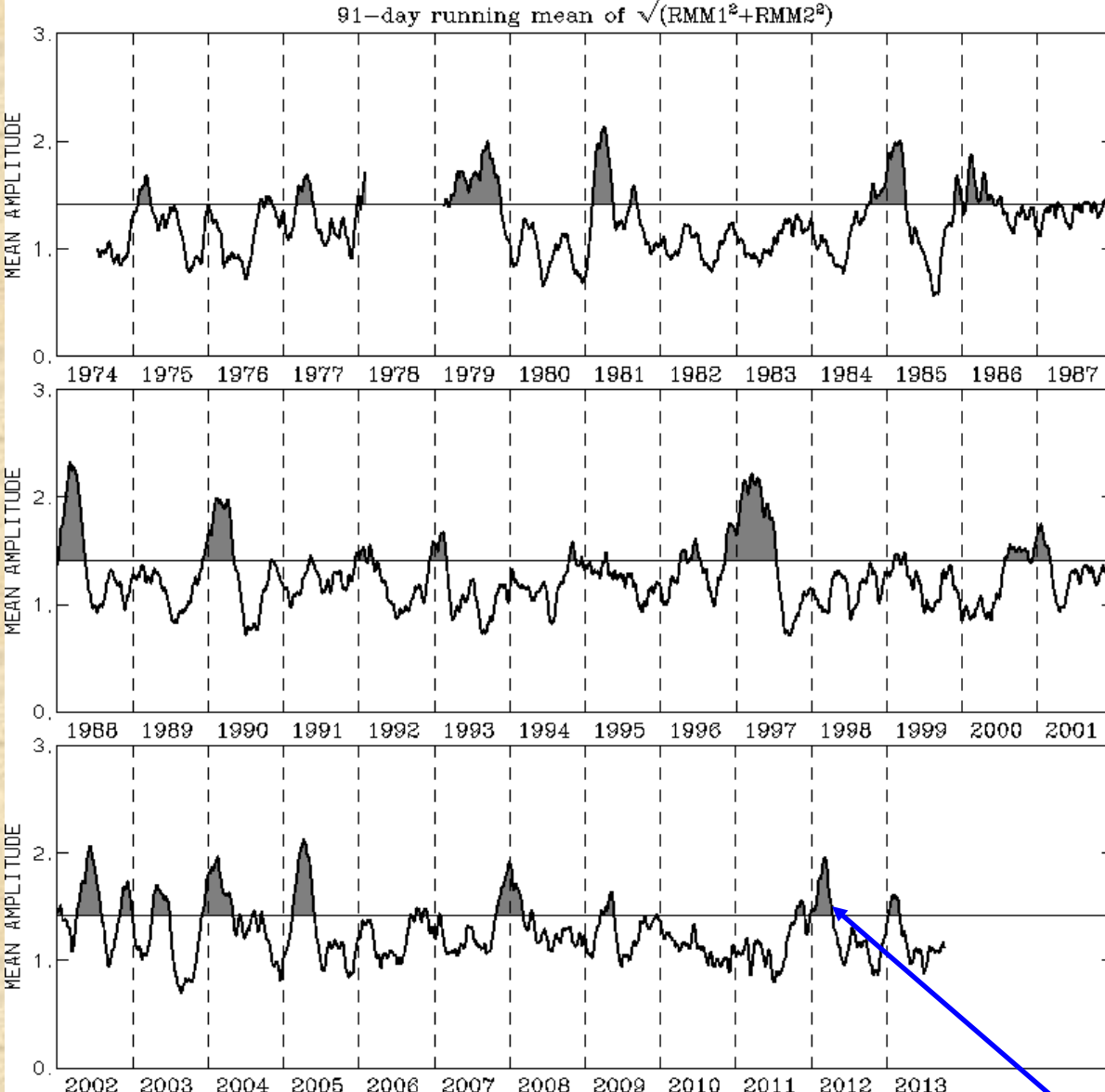
- Current classification of neutral ENSO with negative PDO stacks the odds slightly against Northern CA in particular (El Niño would have made it much more likely to be wet). *El Niño did not come to the rescue*

- Other influences (Indian Ocean, (N)AO, and this summer El Niño-'fling') leave southwestern California with a more favorable outlook than last year. However, the Sierra Nevada appears less likely to benefit from this. In sum, a near-normal runoff season appears most likely in N CA this year, but southern CA may be in for a wetter winter.

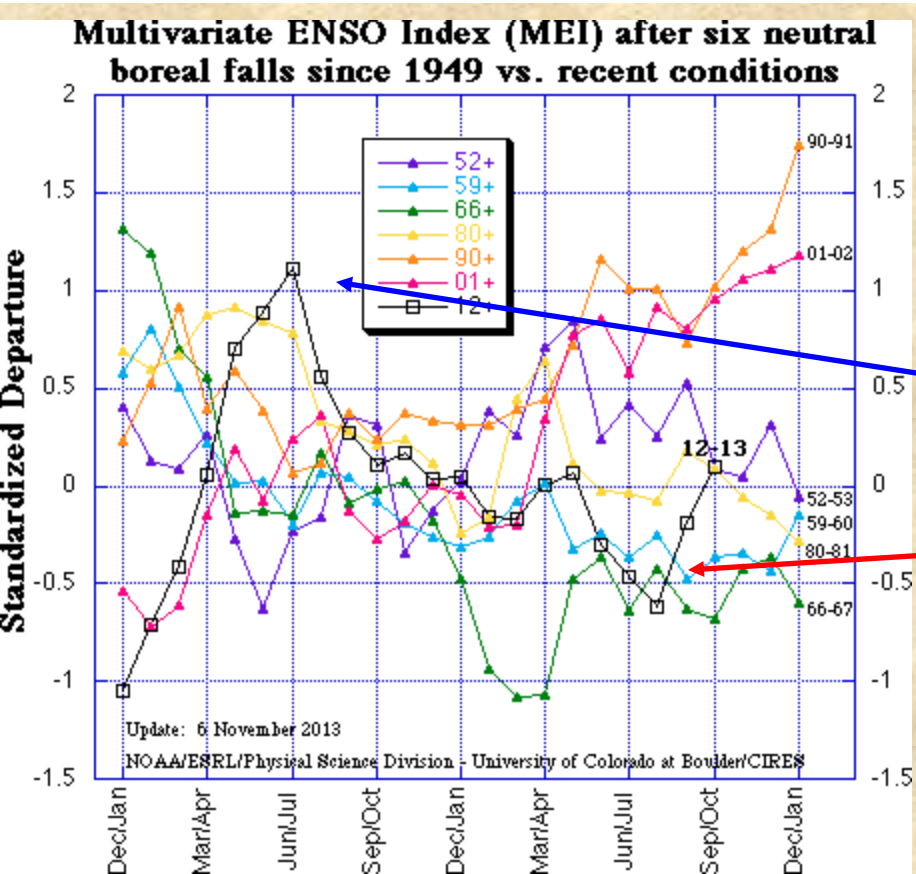
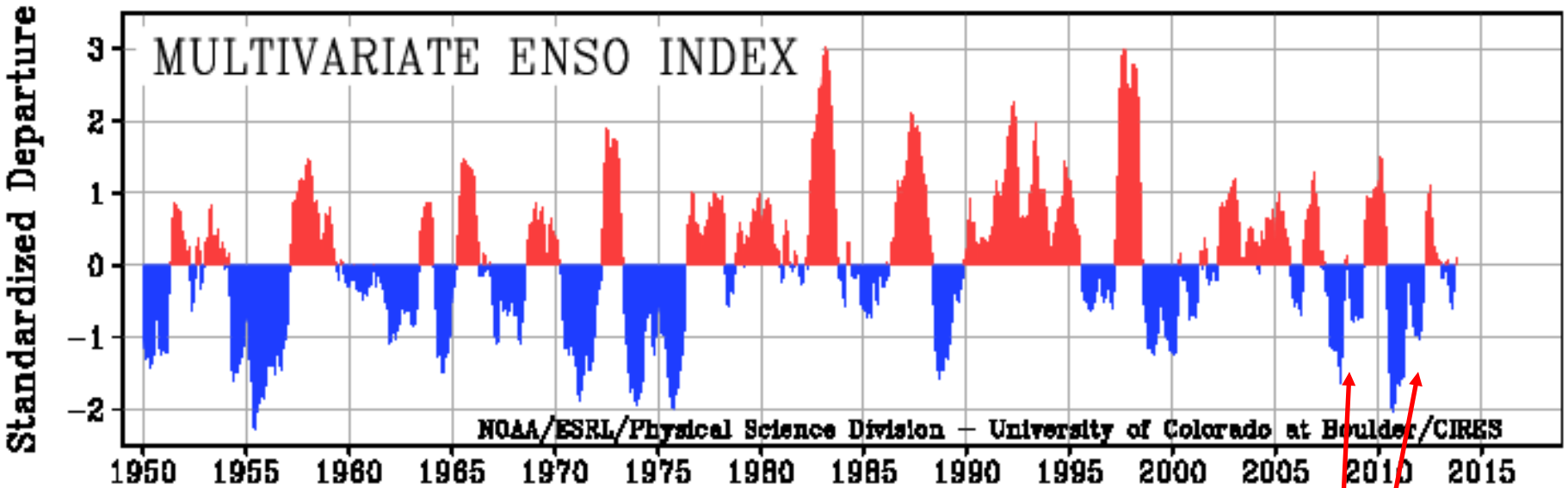
Interesting lack of skill in region with highest average skill (Southern CA)

- Colorado River outlook currently 'bearish', especially if our current dry fall continues. *No correction needed there!*

- Joker in this game: 'Atmospheric River' events – *two early on, then none*

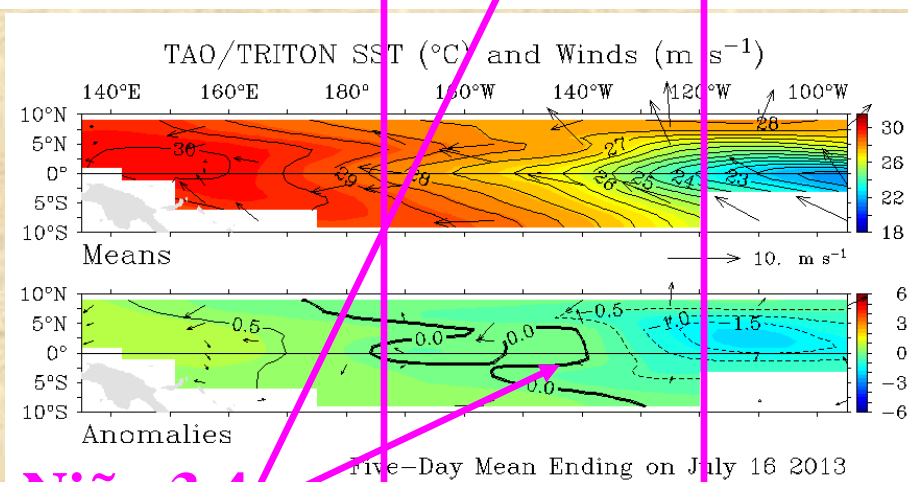
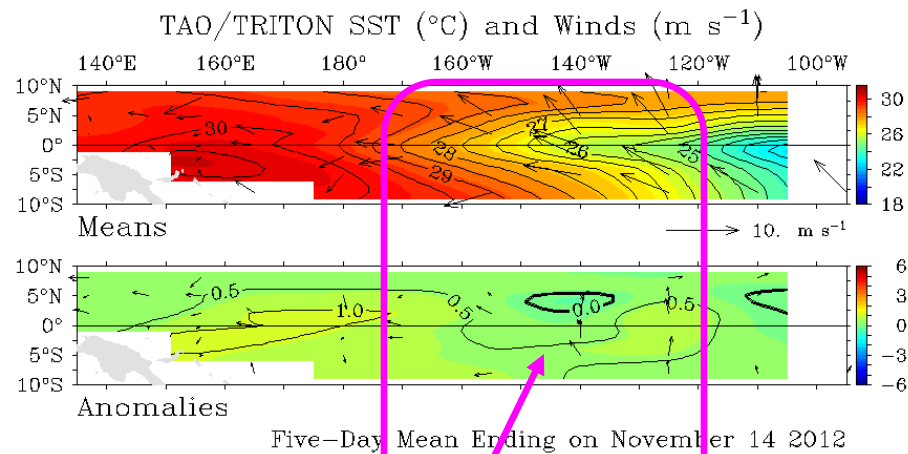


Compared to about a decade ago, intraseasonal 'MJO' activity levels have been mostly on the weak side, with the exception of the early 2012 'Rick Perry' run that almost succeeded in creating an El Niño event during the following summer.

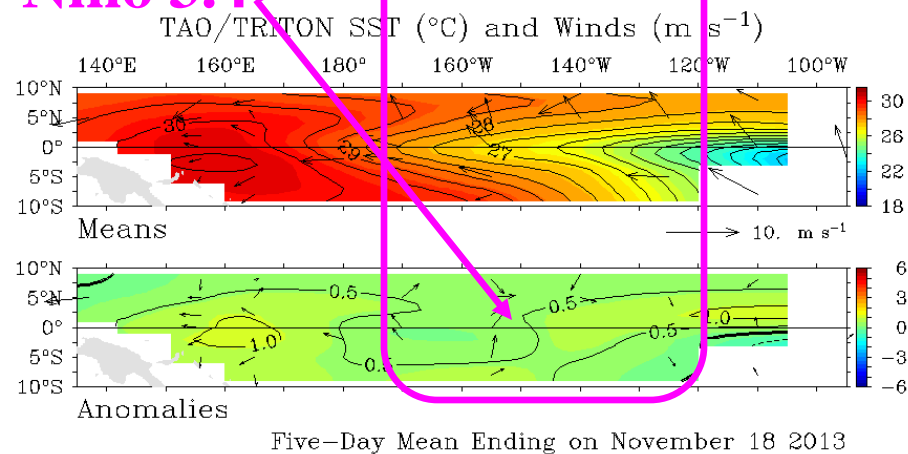


Last five years have seen two 'double-dip' Las Niñas in a row, followed by a brief excursion to what looked like an El Niño event in 2012, a return to ENSO-neutral conditions as of last fall, and a recent dip towards La Niña that appears to have been short-lived.

<http://www.esrl.noaa.gov/psd/enso/mei>



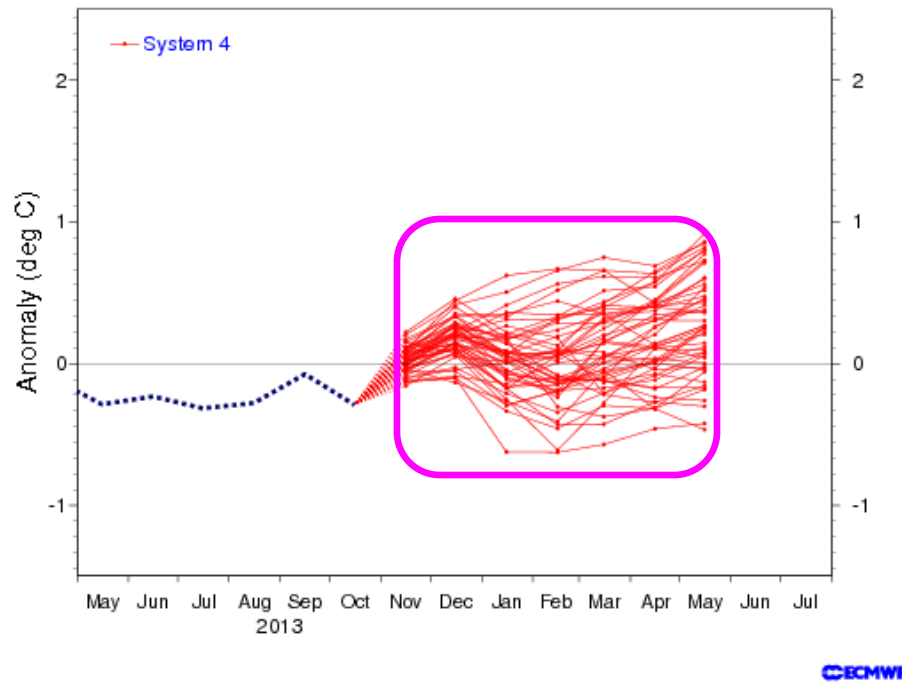
Niño 3.4



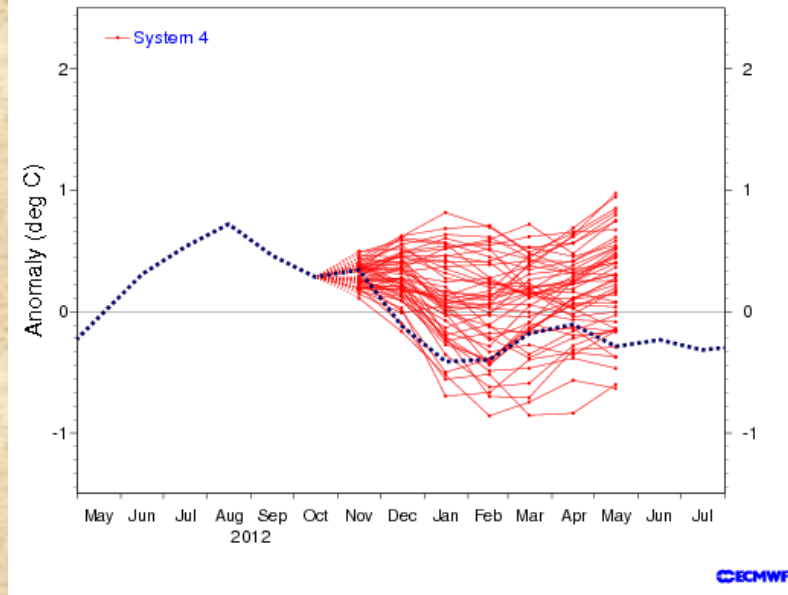
Current state of ENSO (bottom) compared to last fall (top): starting out with highly unusual ENSO- ‘neutral’ condition (top), La Niña appeared on its way back during the summer (middle), only to be replaced by ENSO-neutral again this fall (bottom). Recent wind anomalies have remained weak, and are not conducive to rapid change.

To have two neutral ENSO-winters in a row is fairly uncommon, but not unprecedented – analogous pairs occurred in 52-54, 59-61, 80-82, and 89-91.

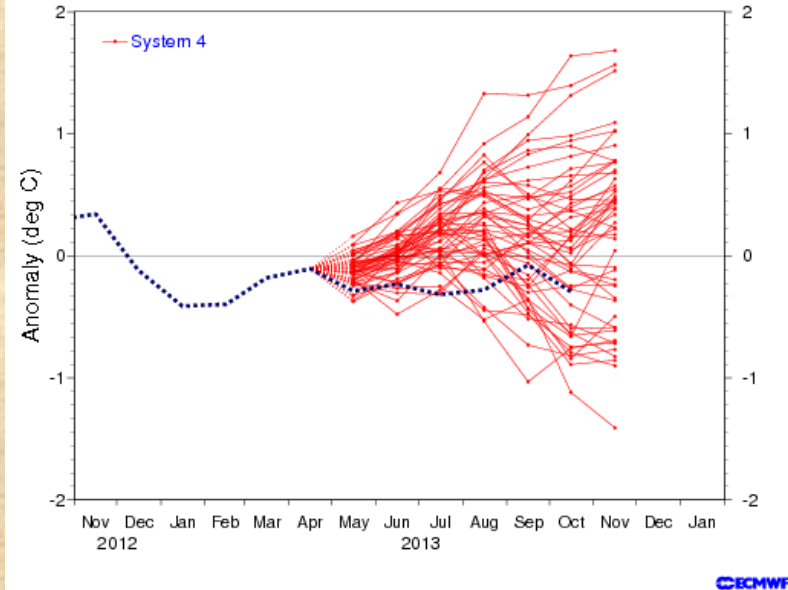
NINO3.4 SST anomaly plume
ECMWF forecast from 1 Nov 2013
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology



NINO3.4 SST anomaly plume
ECMWF forecast from 1 Nov 2012
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology



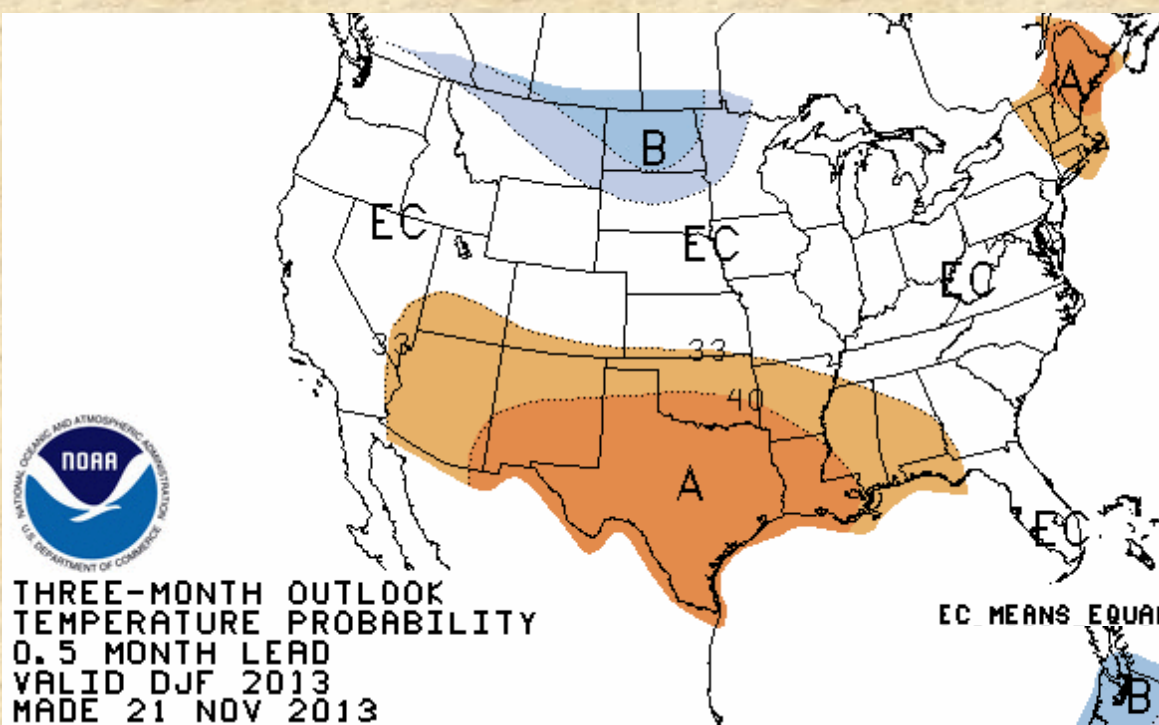
NINO3.4 SST anomaly plume
ECMWF forecast from 1 May 2013
Monthly mean anomalies relative to NCEP OIv2 1981-2010 climatology



European ‘forecast plume’ of Niño 3.4 from this month (top left) predicts more or less neutral ENSO conditions for the next six month. Last fall’s forecast (top right) failed to anticipate the return of mostly negative SST anomalies through the winter and into the summer of 2013 – the same can be said for the spring forecast which was too optimistic about a return to El Niño in 2013 (bottom right).

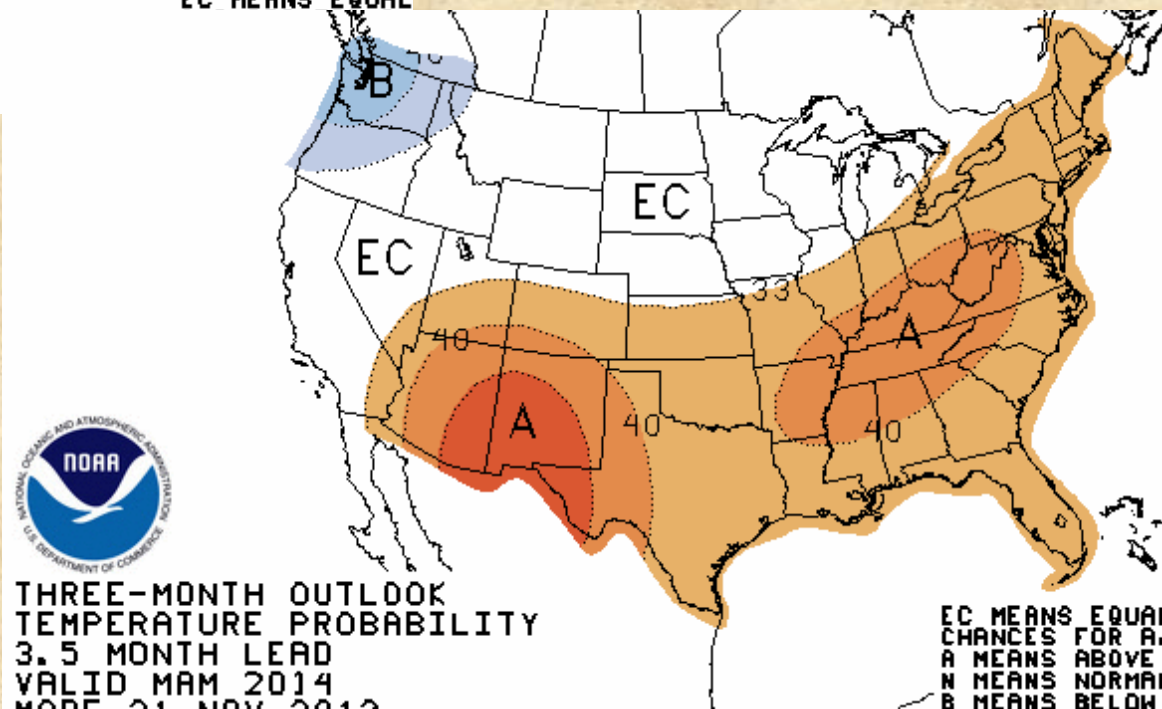
IRI plume not very different – note that statistical models did better in 2013 than dynamical models.

What is the 'official' word from the Climate Prediction Center?

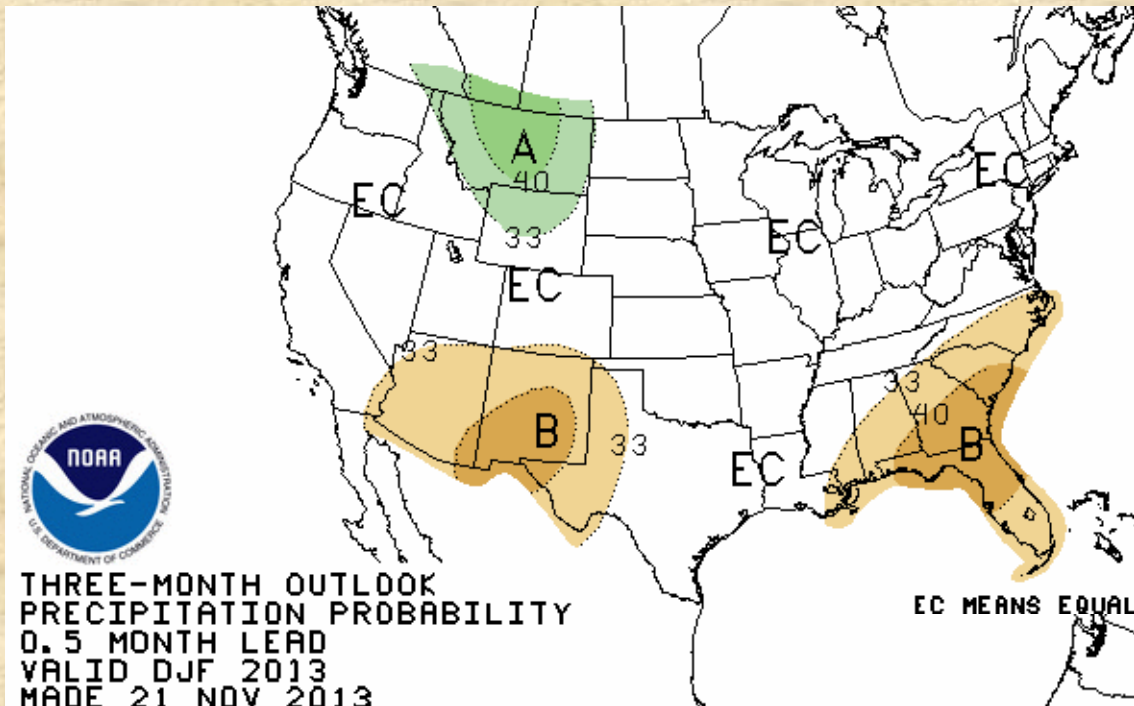


Temperature forecasts are based on blend of tools, mostly the NMME which in turn 'feel' the negative PDO and positive AMO in its initial conditions. Neutral ENSO is anticipated to continue and is not adding color to the maps.

California is left 'EC' – partially because it has not shown much of a warming trend.

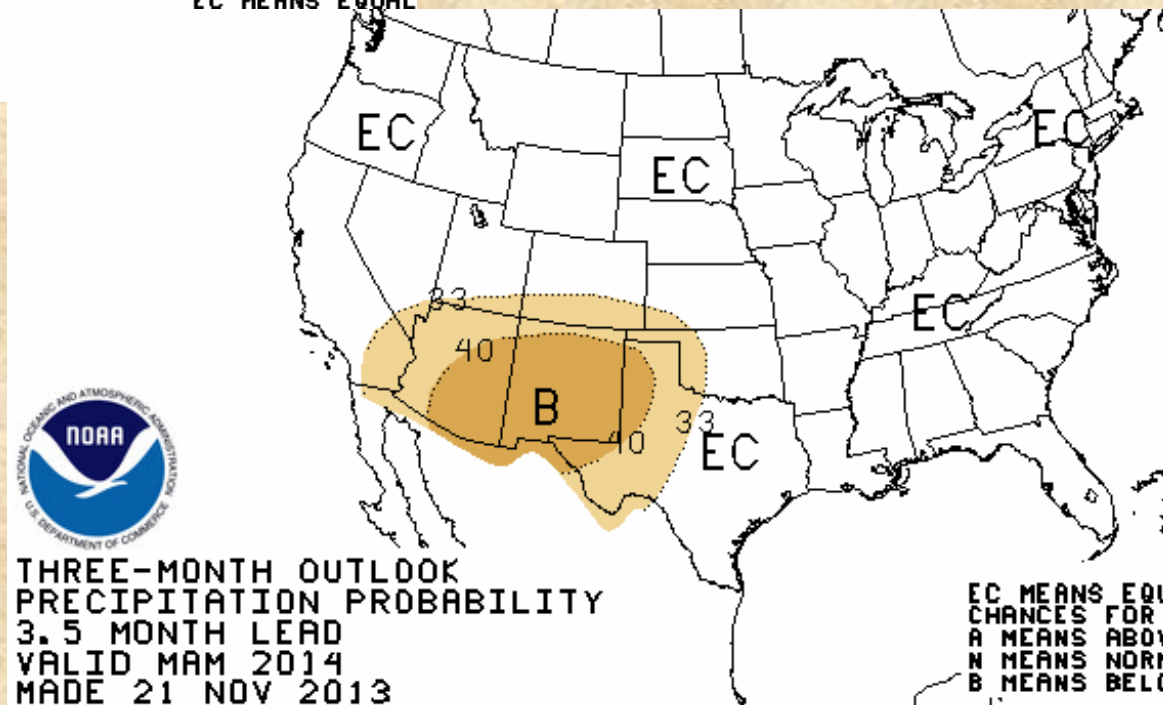


What is the 'official' word from the Climate Prediction Center?



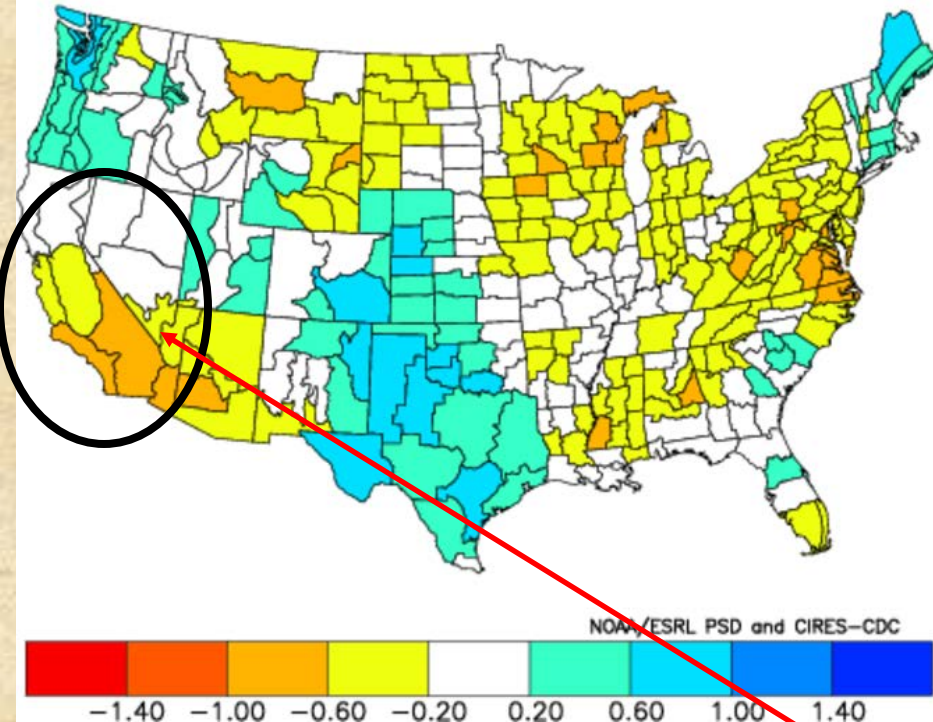
Precipitation forecasts are based on blend of tools, mostly the NMME which in turn 'feel' the negative PDO and positive AMO in its initial conditions. Neutral ENSO is anticipated to continue and is not adding color to the maps.

California is left 'EC'
– just to spite
Jeanine....

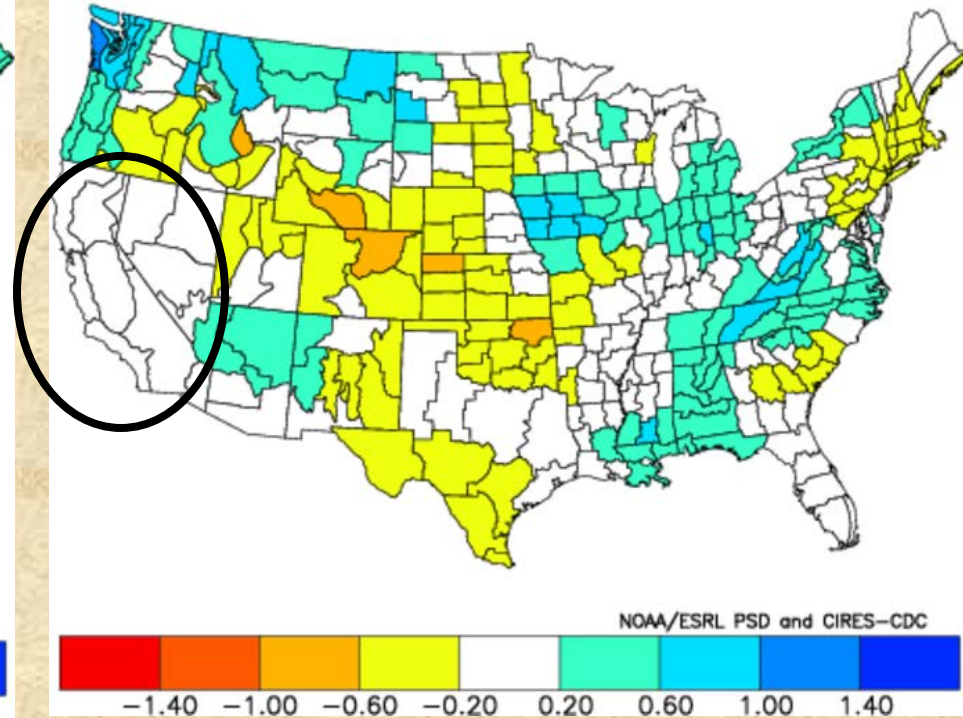


2nd year ENSO-neutral composites

Composite Standardized Precipitation Anomalies
Oct to Dec 1953, 1960, 1981, 1990
Versus 1950–1995 Longterm Average

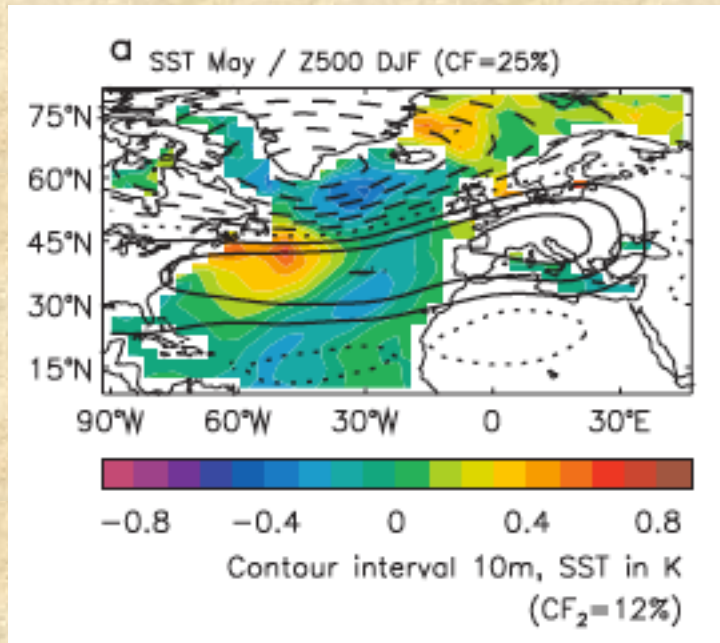


Composite Standardized Precipitation Anomalies
Jan to Mar 1954, 1961, 1982, 1991
Versus 1950–1995 Longterm Average



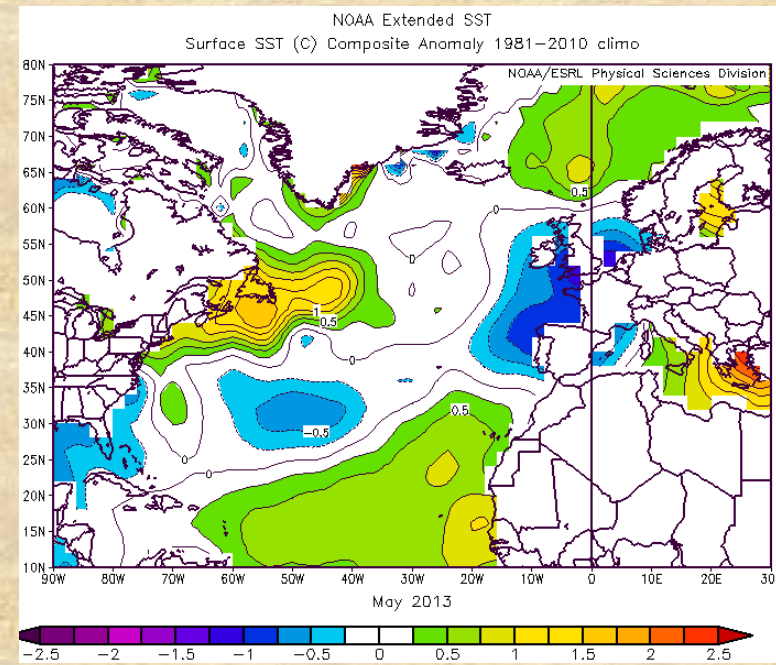
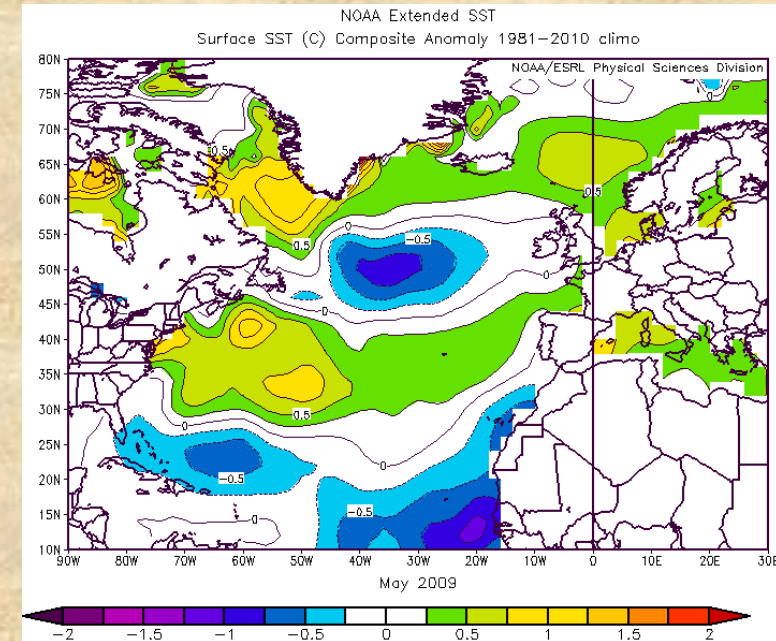
Using four analog cases with 2nd year ENSO-neutral conditions, the precipitation odds for the 2nd year fall (Oct-Dec; left) are dry in southern CA (orange), and neutral to the north (white). This is succeeded by neutral odds in the subsequent late winter season (Jan-Mar; right). The sample is so small that this should be considered for curiosity only.

Other factors: (N)AO

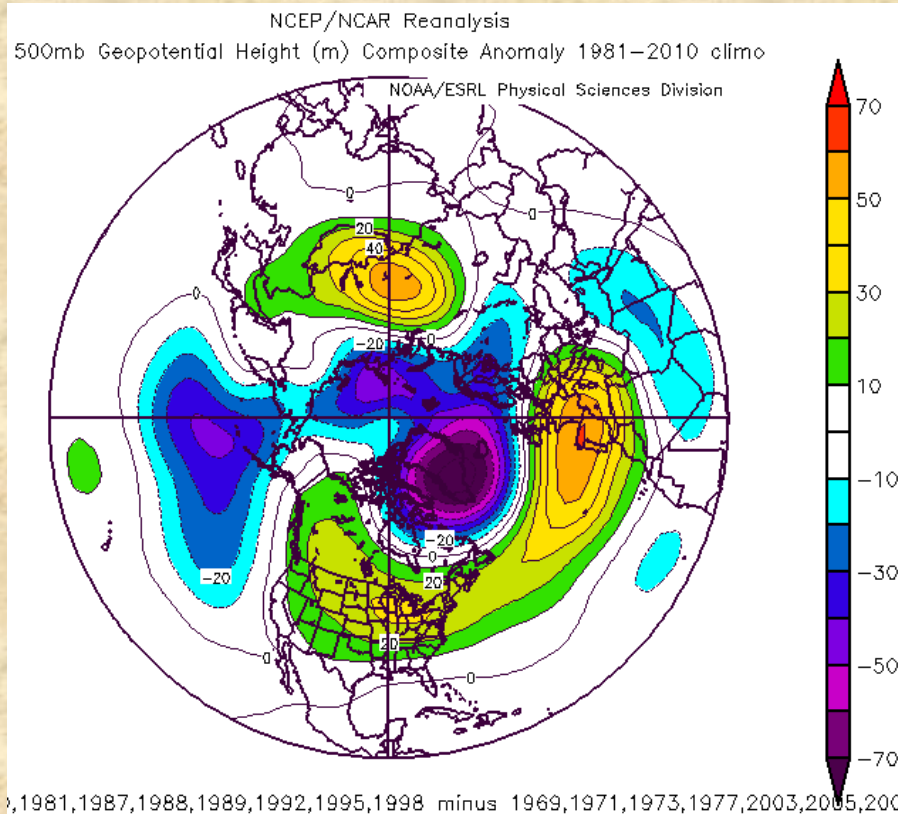


May SST pattern that projects onto subsequent positive NAO phase (top left); 2009 SST (top right) anticipated negative NAO (if not as extreme as observed), while 2013 (bottom right) looks closer to positive NAO (as in 2012)...

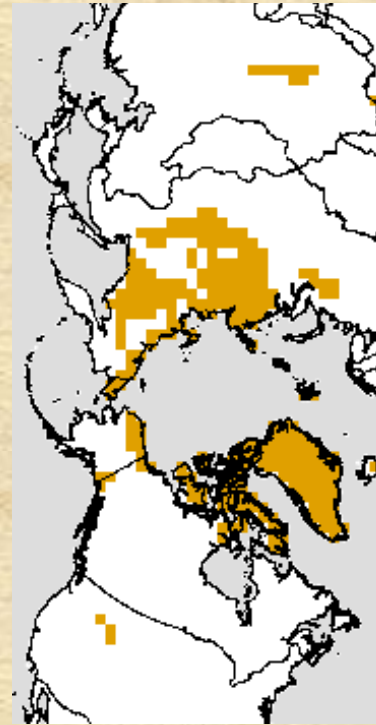
Source: Rodwell & Folland (2002)



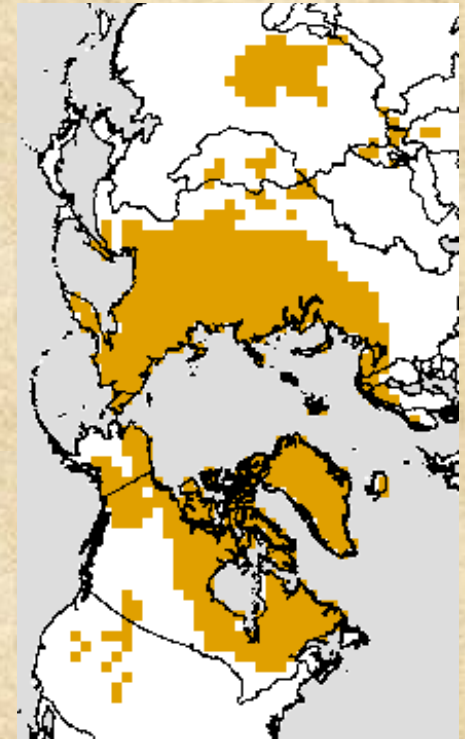
October Snow cover? (Riff on Judah Cohen)



30 Sep'13



31 Oct'13

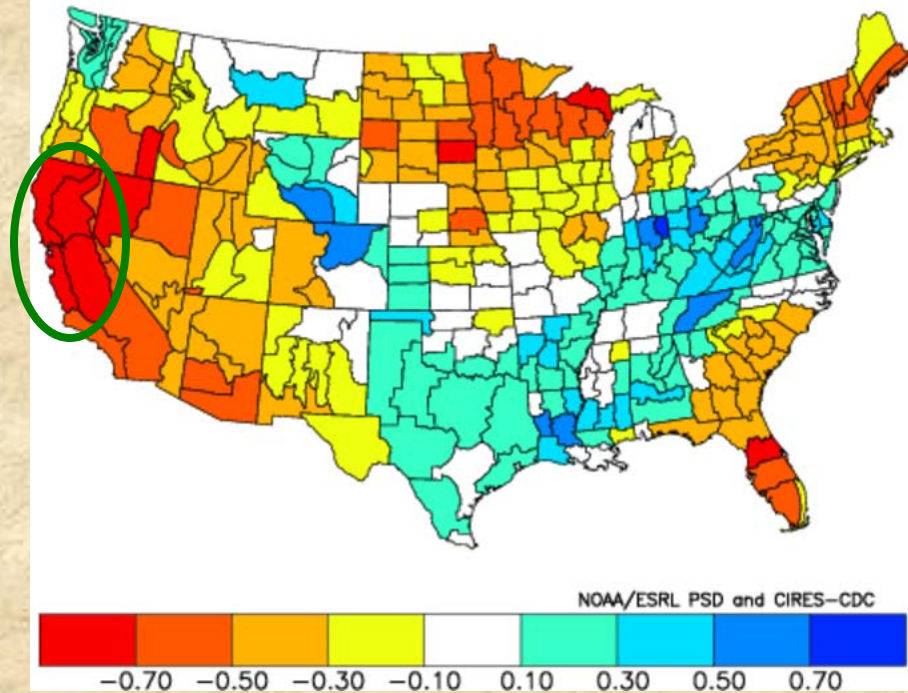


Eurasian Snowcover: $\Delta(\text{October-September})$ – the composite shows 8 smallest increases minus 8 biggest ones to give us a positive NAO signature, for DJFM 500mb (top left). Evolution of this year's snowcover expansion puts it into the category of one of the 8 biggest increases, i.e. favoring a negative NAO just like last year (which did not happen). Note that the 'AO' was negative last winter, in unusual contrast to the 'NAO'.

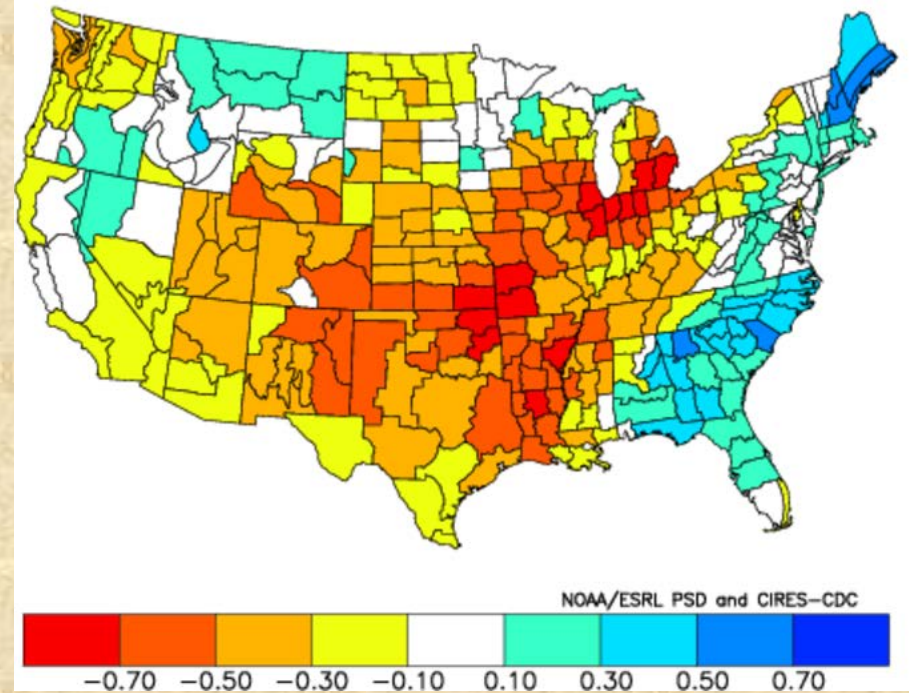
Data: <http://climate.rutgers.edu/snowcover/>

Neutral ENSO vs. NAO+ (left), or NAO- (right)

Composite Standardized Precipitation Anomalies
Oct to Mar 1948–49, 1956–57, 1960–61, 1966–67, 1989–90, 1993–94, 2006–07, 2011–12
Versus 1950–2007 Longterm Average



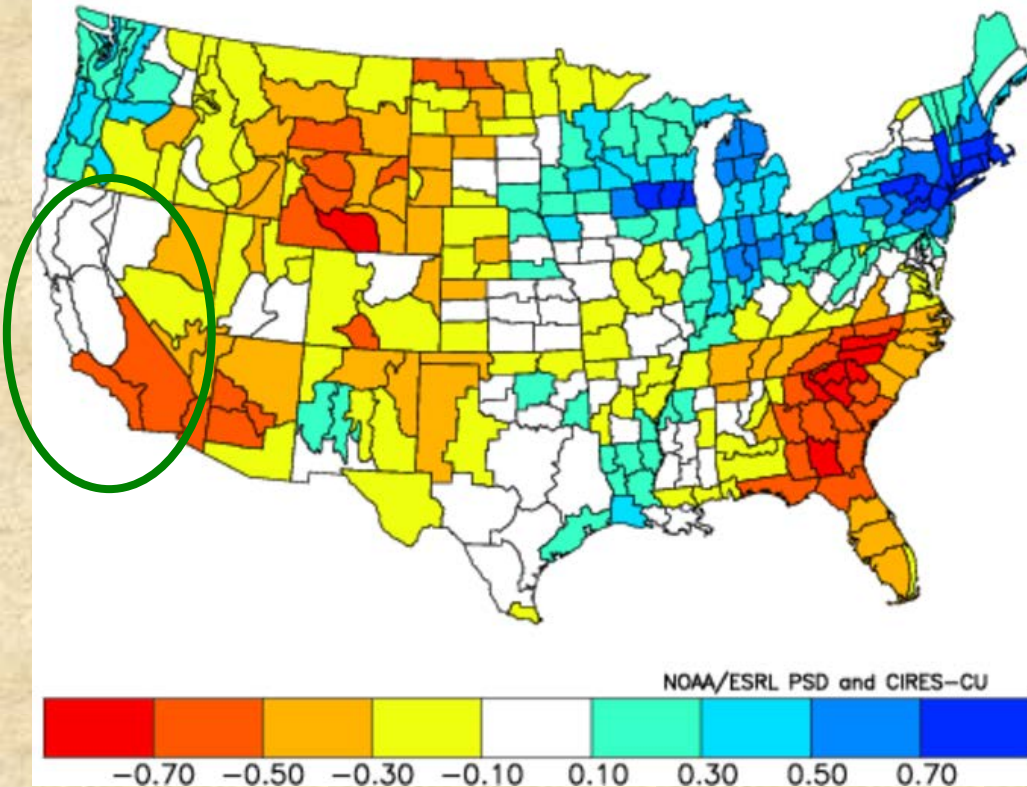
Composite Standardized Precipitation Anomalies
Oct to Mar 1962–63, 1963–64, 1964–65, 1968–69, 1976–77, 1978–79, 1995–96, 2005–06
Versus 1950–2007 Longterm Average



During positive NAO and neutral ENSO conditions (left), the winter half-year (Oct–Mar) tends to be much drier than normal in CA, while the negative NAO case (right) is similar to tossing a coin. Recent NAO values have been quite low in October, but rebounded to positive in November, with no clear trend one way or the other for the next two weeks.

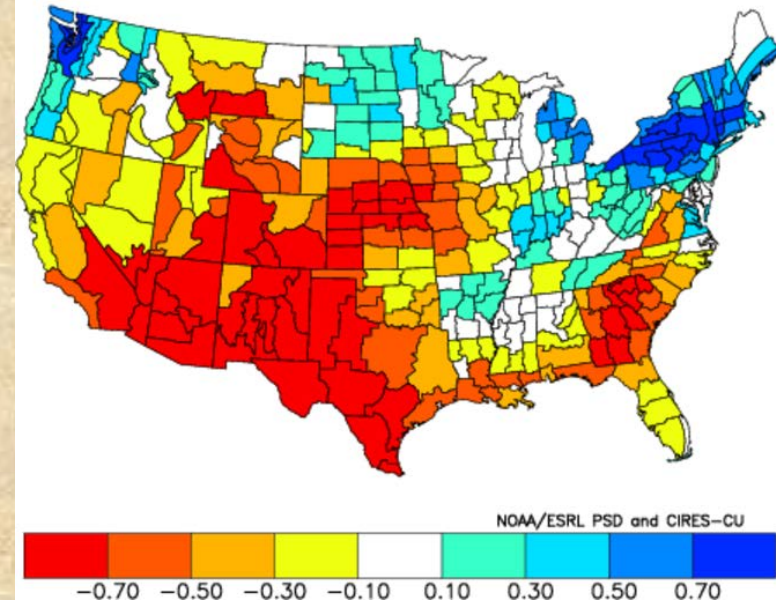
What might happen in WY'14 – the PDO-AMO angle?

Composite Standardized Precipitation Anomalies
Versus 1895–2000 Longterm Average
Oct to Sep 1932–33, 1937–38, 1939–40, 1950–51, 1951–52, 1960–61, 2000–01, 2001–02
2005–06, 2006–07,



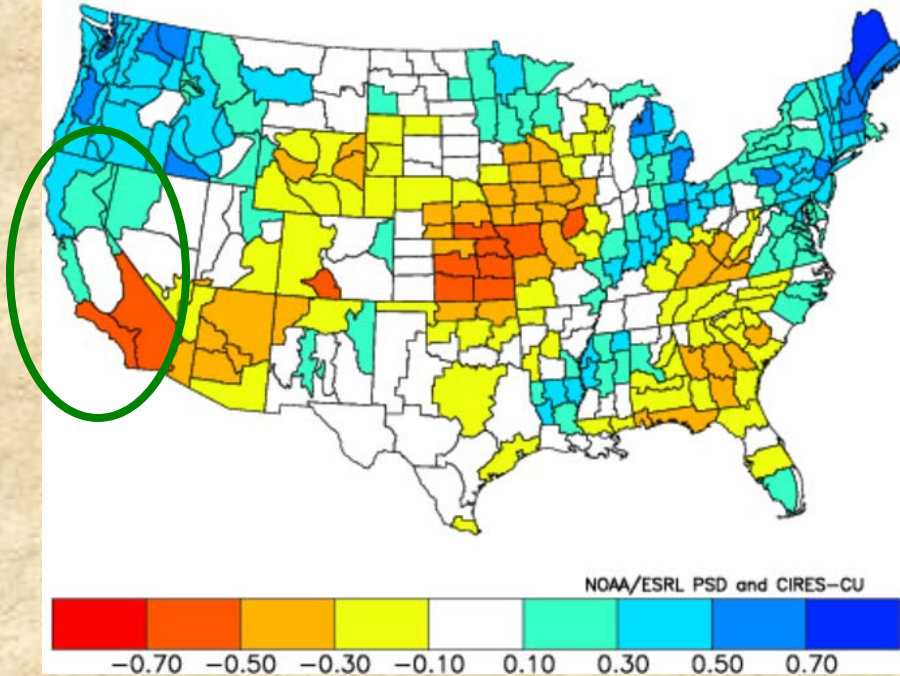
This year (left) versus last year's composite (bottom) – same basic idea, but not as lopsided as last year

Composite Standardized Precipitation Anomalies
Versus 1895–2000 Longterm Average
Oct to Sep 1933–34, 1944–45, 1952–53, 1955–56, 1998–99, 1999–00, 2001–02, 2008–09
2010–11, 2011–12,

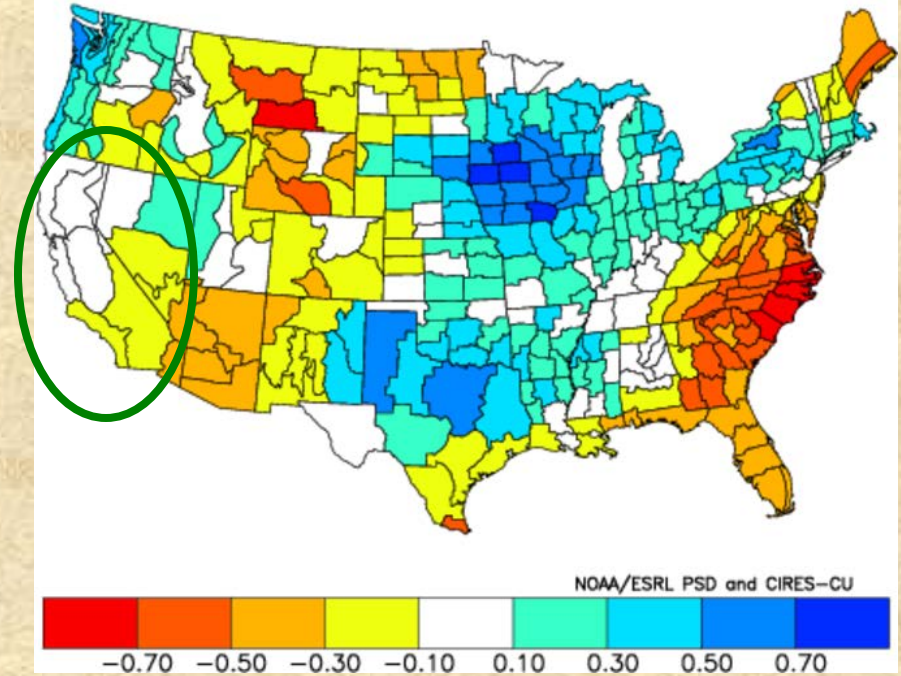


What might happen in WY'14– the PDO-AMO angle?

Composite Standardized Precipitation Anomalies
Oct to Dec 1932,1937,1939,1950,1951,1960,2000,2001,2005,2006
Versus 1895–2000 Longterm Average

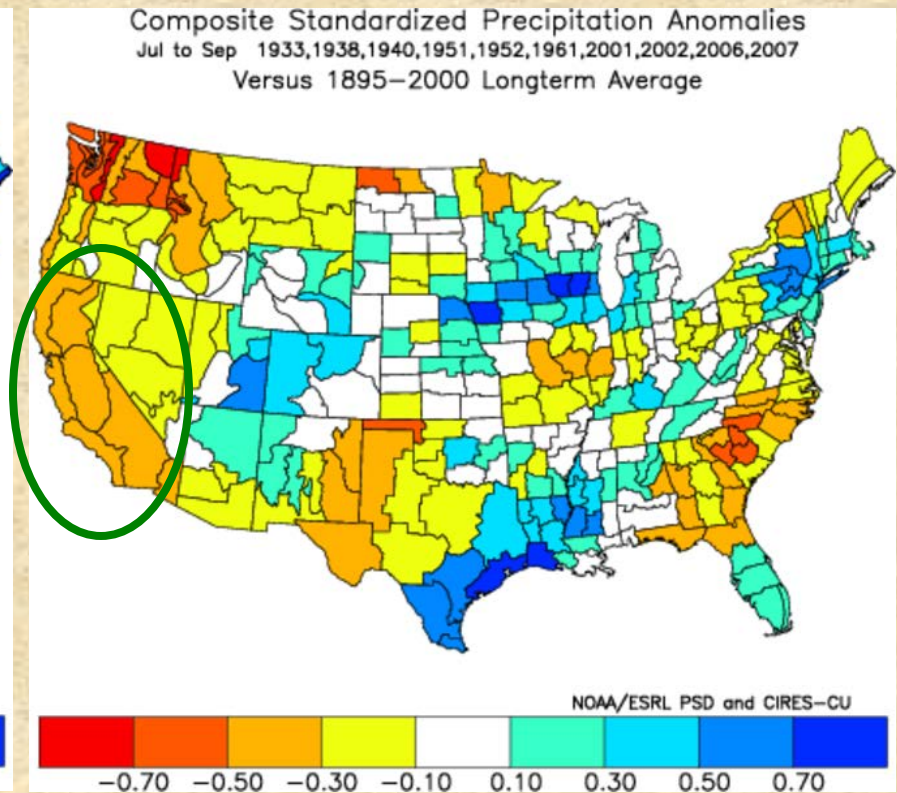
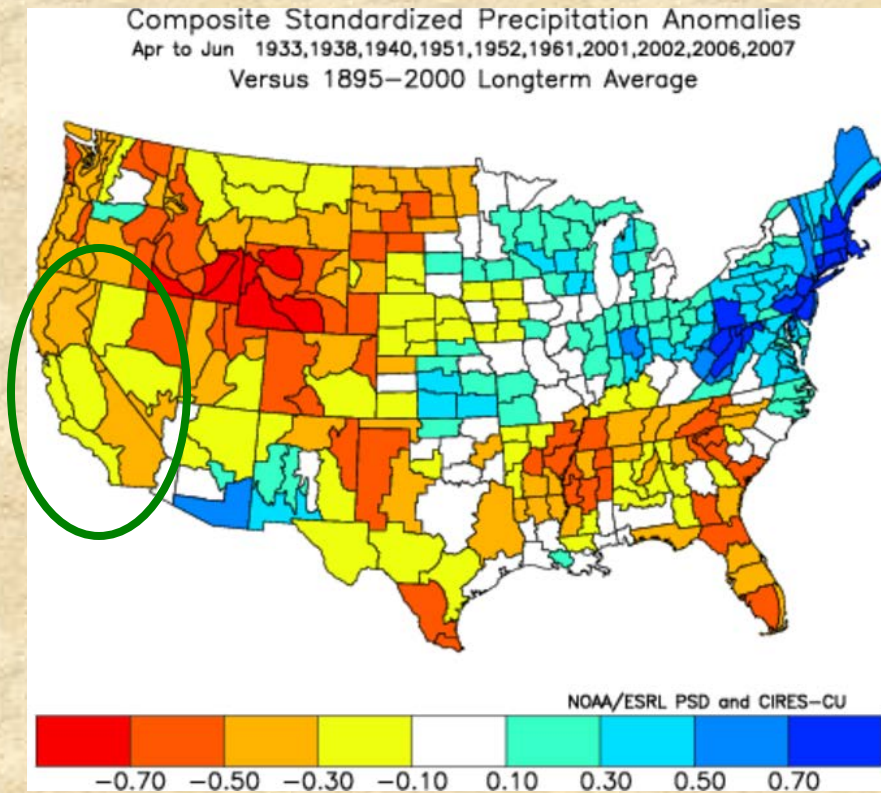


Composite Standardized Precipitation Anomalies
Jan to Mar 1933,1938,1940,1951,1952,1961,2001,2002,2006,2007
Versus 1895–2000 Longterm Average



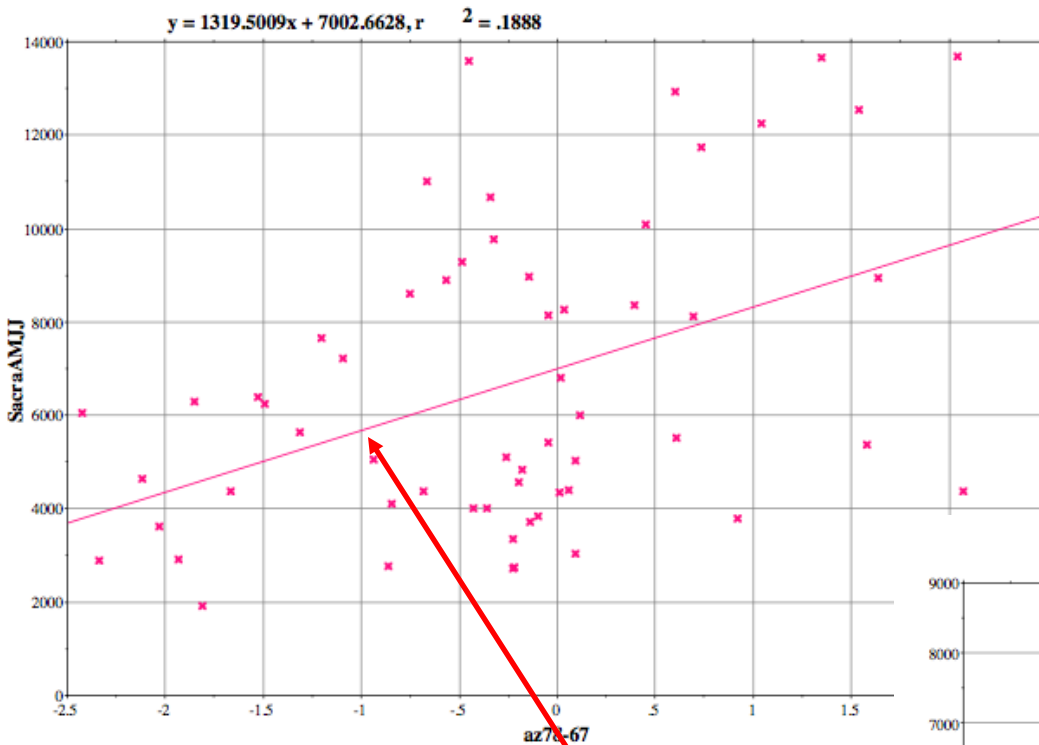
Not as pronounced a 'forecast' as last year for this part of the U.S. in the wake of a less extreme PDO-AMO summer (ranked 17th out of over 100, as opposed to 1st last year). BUT, a familiar theme is hinted at: wettish in northern CA early on, and dryish in the south, especially in OND (left; verification so far is DRY all over since October 1st), and to some extent in JFM (right), but the implied tilt in odds is quite low for the latter.

What might happen in WY'14– the PDO-AMO angle?

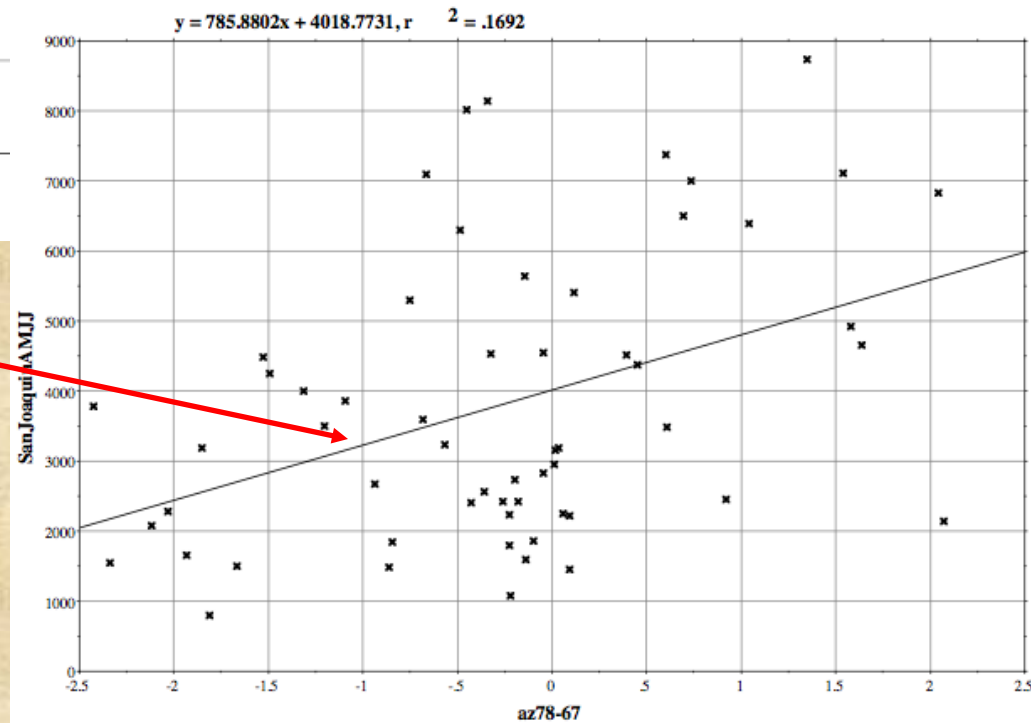


Definitely sounding a dry theme yet again for the western U.S., including CA, this time pretty much up and down the coast for AMJ (left) and JAS (right). Again, this is just for curiosity, I don't attribute much skill to this tool this far out.

Azores high behavior during summer – precursor to NAO?!



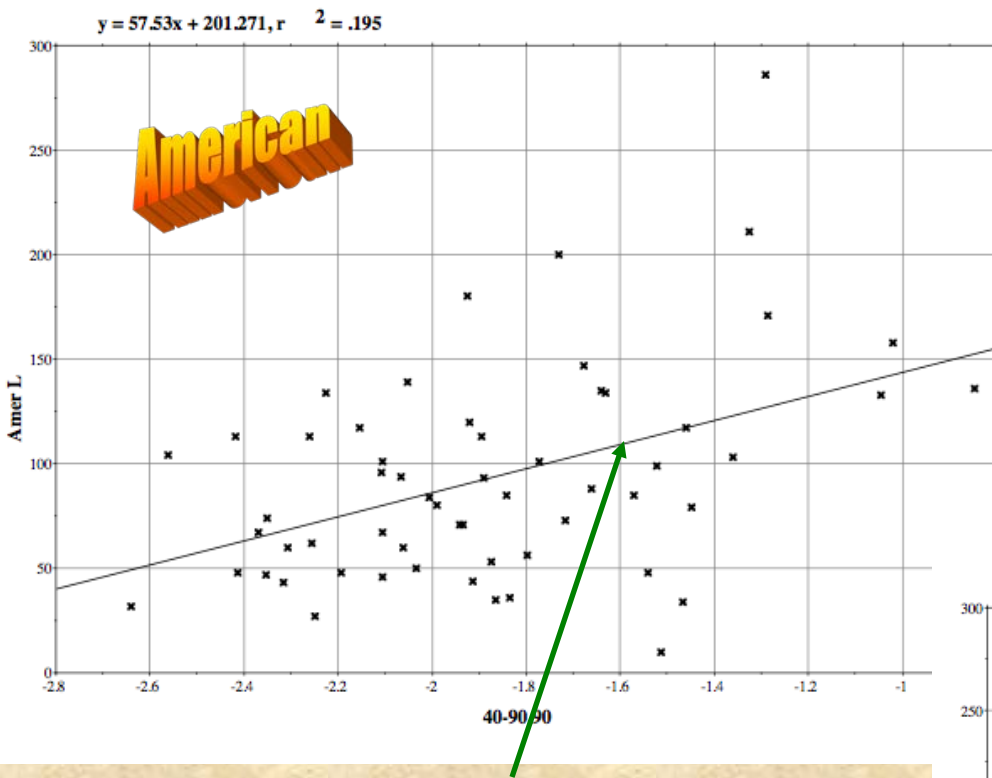
Summer trend in SLP near Azores: Rising pressure in this region is often followed by good runoff in Sacramento and San Joaquin basins – 2009 was the last year to be set-up that way...



2013: -1.025
2012: -.525
2011: -.945
2010: -1.025
2009: +1.770
2008: 0.065

2013

Indian Ocean Dipole - particularly influential in sub-basins

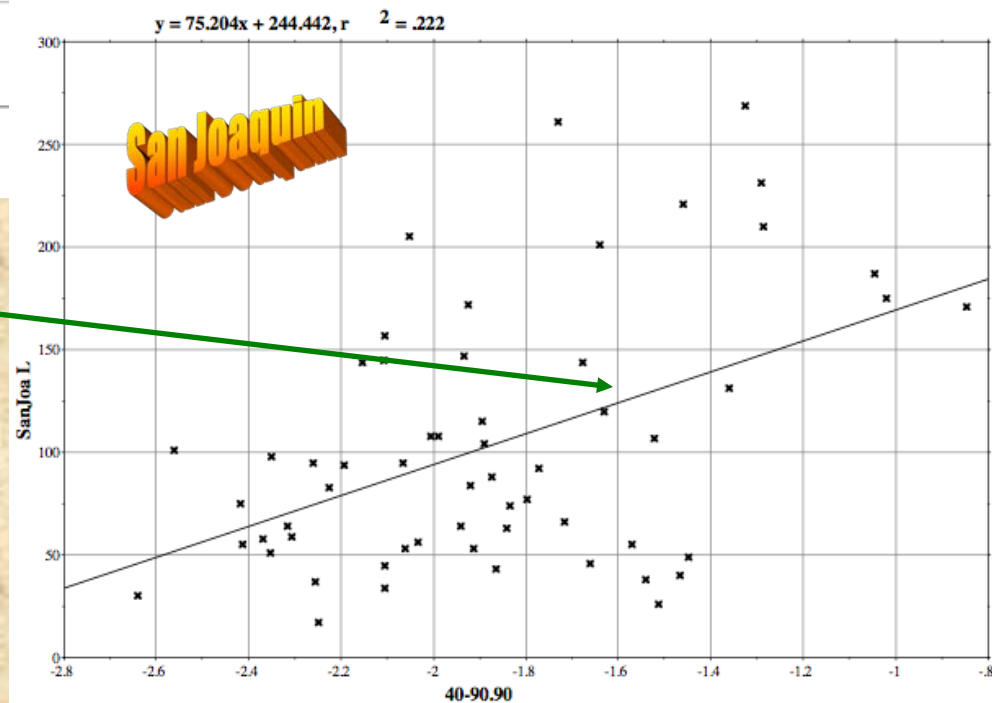


2013

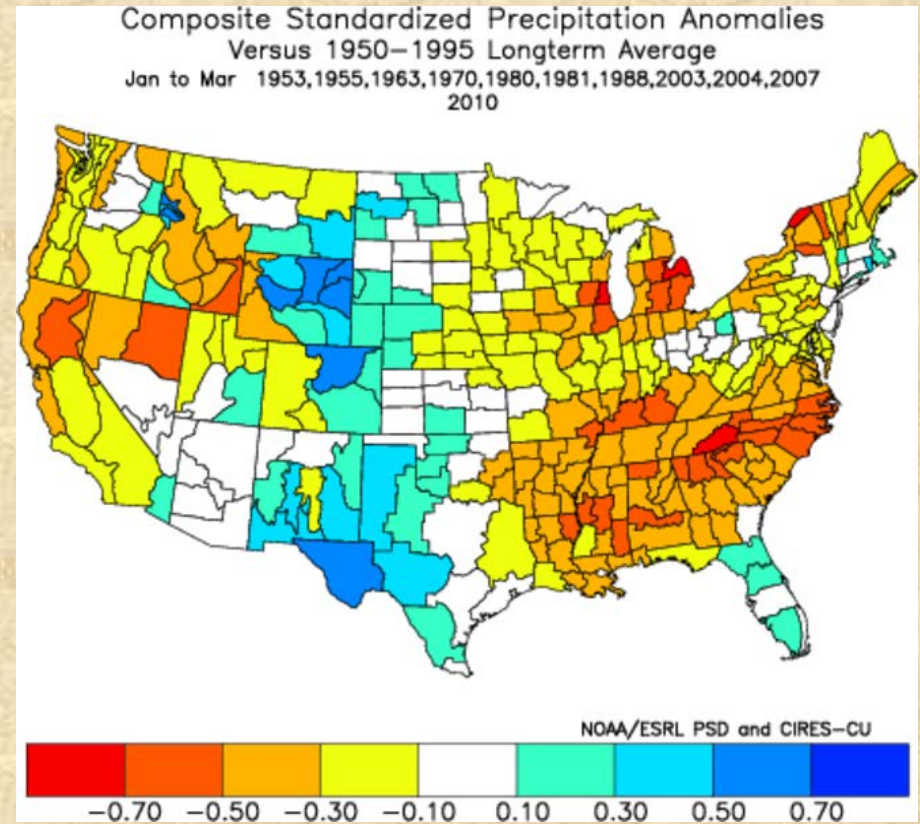
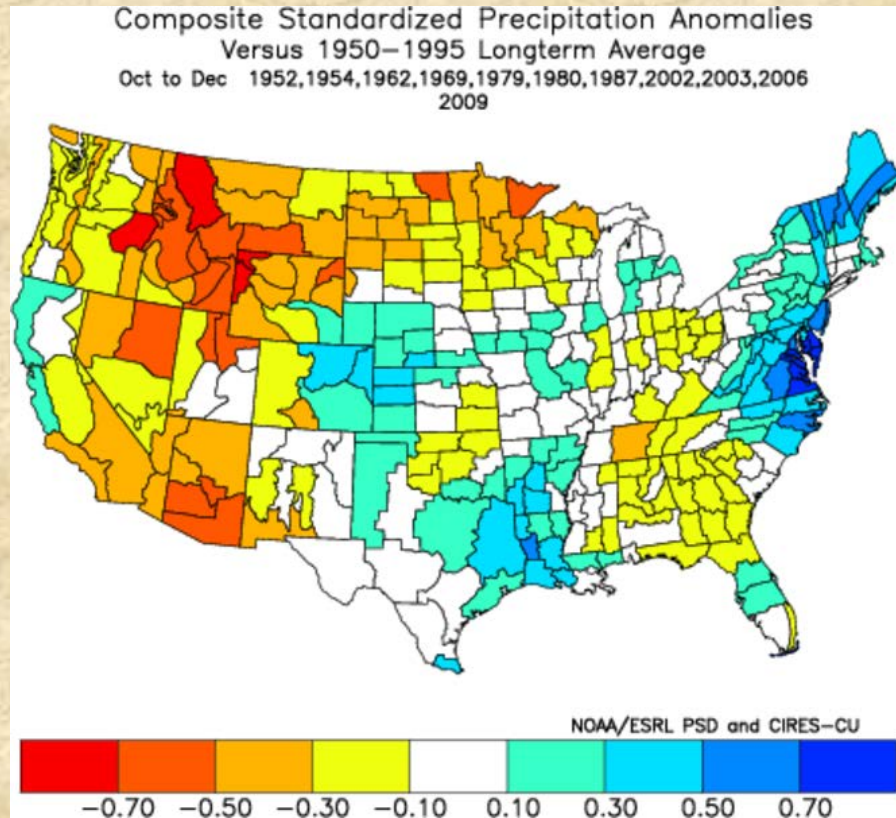
2008: -2.254; 2009: -1.304;
2010: -2.448; 2011: -2.132
2012: -.765 (highest on record)
2013: -1.610

Caveat emptor: Pirates' hole

Fall IOD: Relatively cool SST near Indonesia vs. relatively warm western Indian Ocean is linked to increased April 1 snowpack in American (left) and San Joaquin basins (bottom; both lower elevation indices). *Based on this association alone, 2013-14 looks 'near-normal'!*



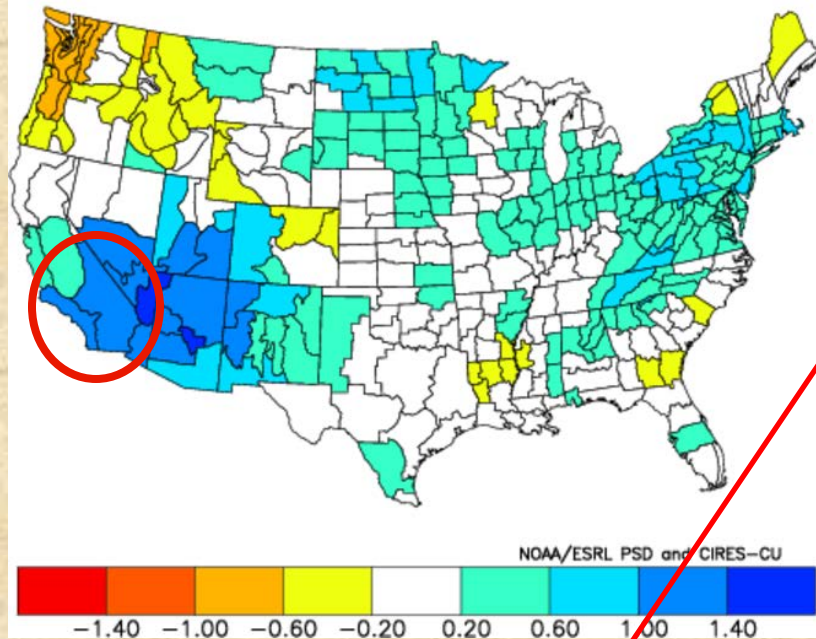
Fairbanks October warmth



After several cold fall seasons, interior Alaska remained very warm in October. This is typically associated with dry weather in Oct-Dec over much of the interior the western U.S. (left), but apparently allows for wetter conditions along the CA coast. In subsequent late winters (right), the overall pattern has tended to stick around over the Western U.S., but drying out in Northern CA.

Note that about half of these cases are associated with El Niño, not likely in near future.

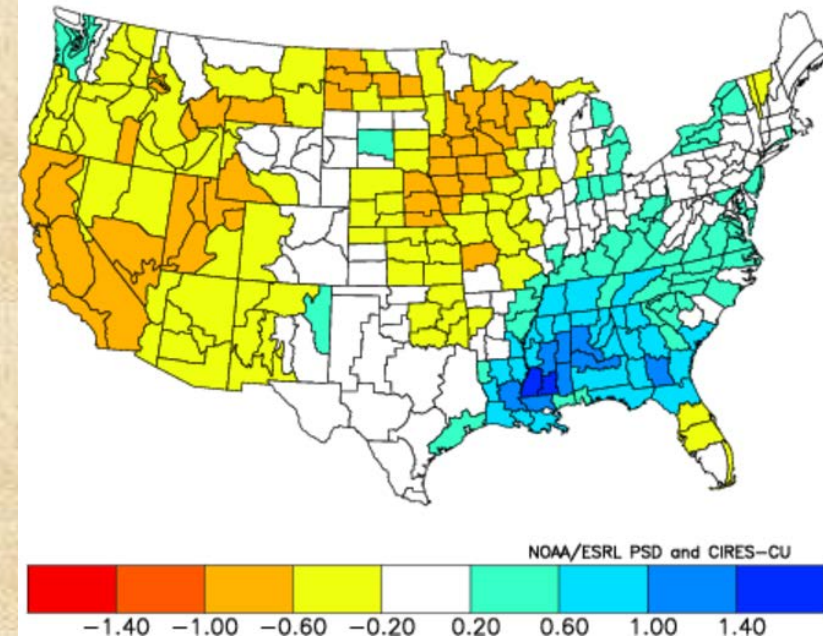
Composite Standardized Precipitation Anomalies
Dec to Feb 1992-93, 2002-03, 2004-05, 2008-09, 2009-10
Versus 1981-2010 Longterm Average



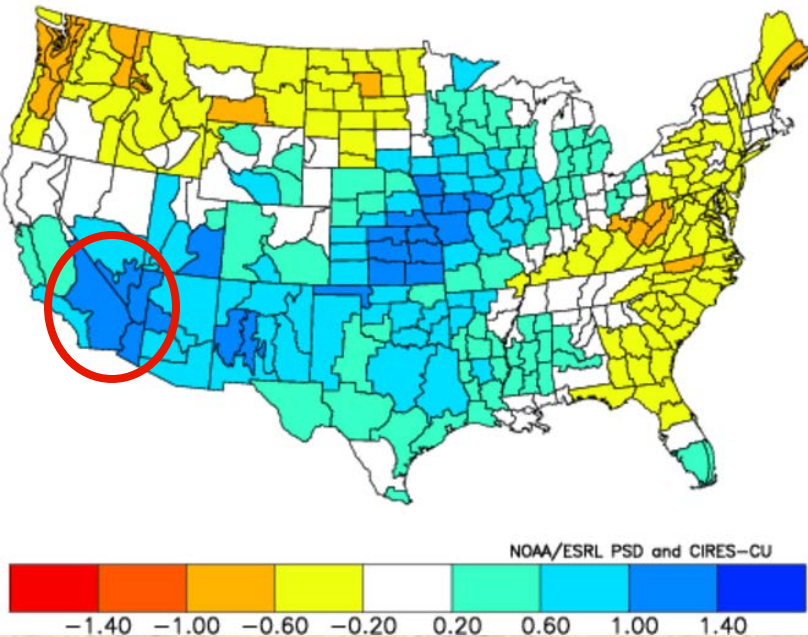
Regional sea-ice linkages

Laptev Sea off the coast of Siberia appears to have a nifty precursor in Feb-Mar ice extent (and, no, there is little trend in that particular variable), but the number of data points is limited (starting in 1979). As best as I can tell, Feb-Mar 2013 was a bit on the high end (top left composite), so southern CA is getting a boost in that scenario.

Composite Standardized Precipitation Anomalies
Dec to Feb 1986-87, 1989-90, 1990-91, 2005-06, 2012-13
Versus 1981-2010 Longterm Average



Composite Standardized Precipitation Anomalies
Dec to Feb 1982-83, 1992-93, 2000-01, 2004-05, 2011-12
Versus 1981-2010 Longterm Average

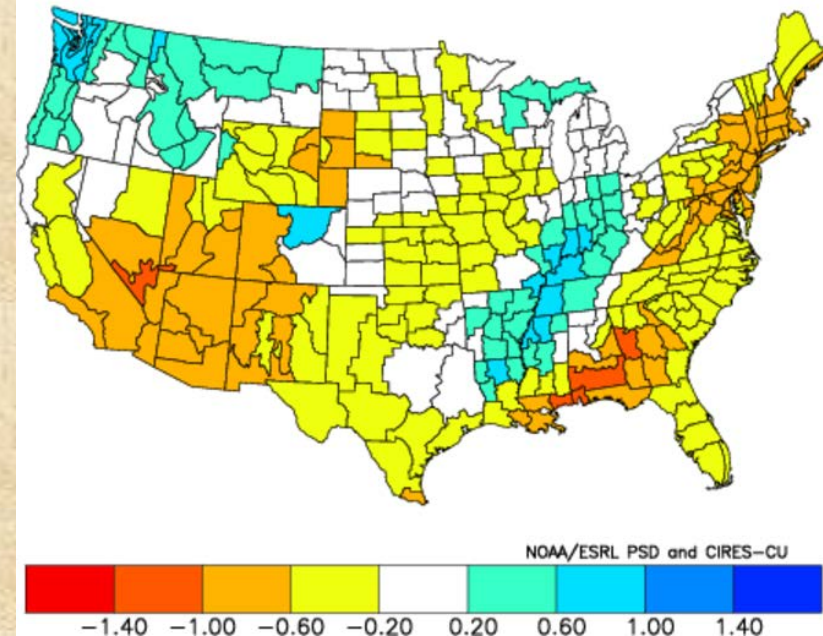


Regional sea-ice linkages

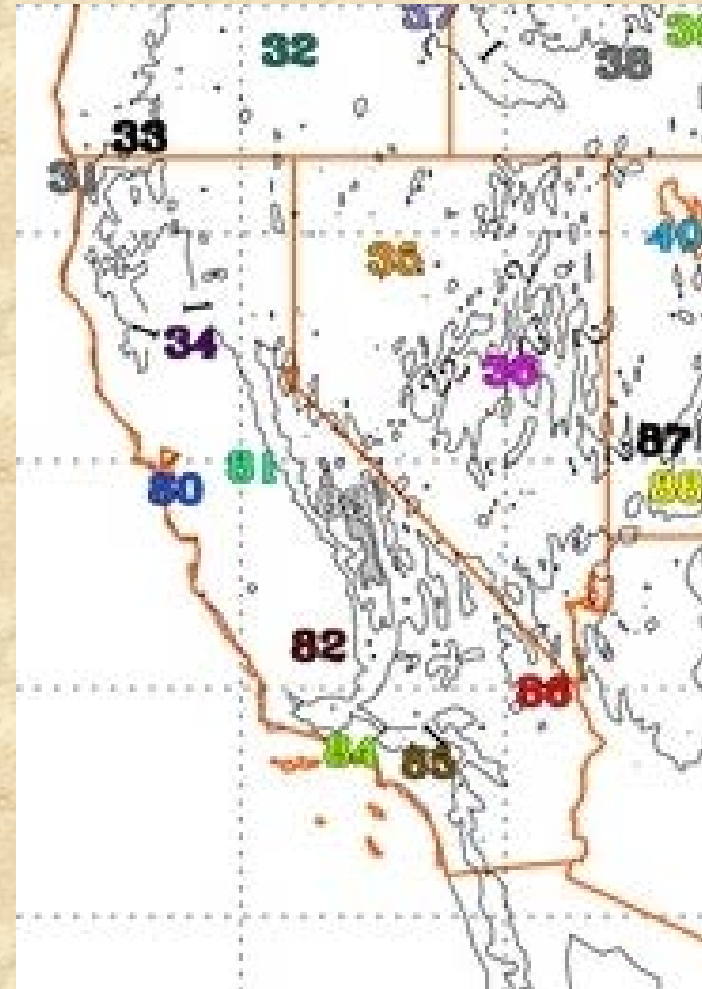
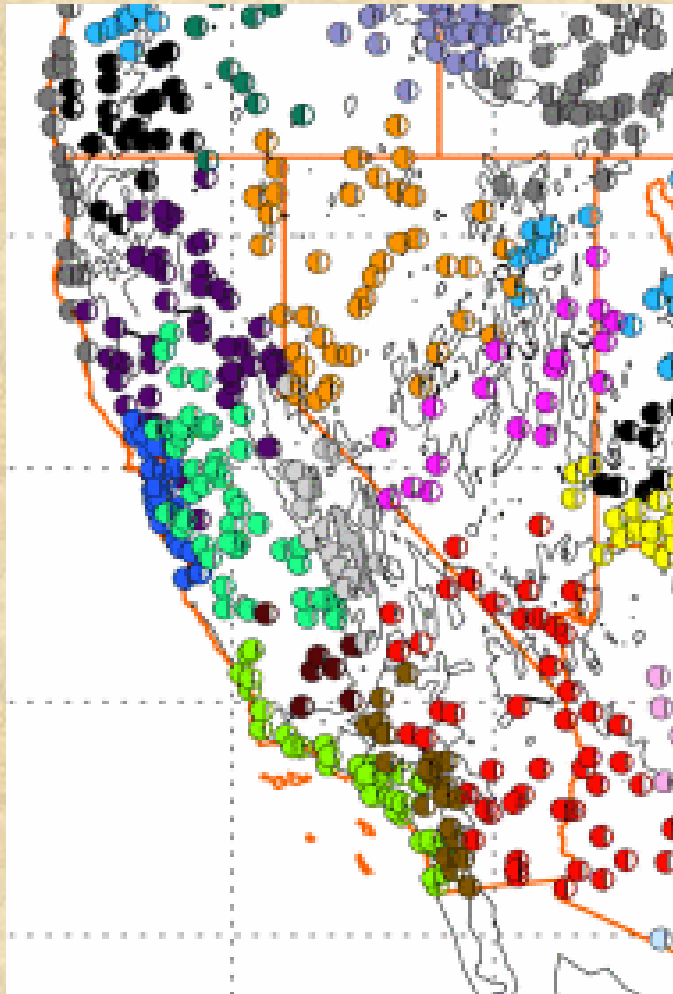
(did I mention that this is new work?)

Hudson Bay difference between late winter and late summer is also positive correlated with southern CA winter wetness. Here is a consistent sea ice predictor that is somewhat independent from the previous one (there is an overlap of two out of five cases for the high end scenario, and one out of five for the low end scenario). 2013 leans wet, again...

Composite Standardized Precipitation Anomalies
Dec to Feb 1988-89, 1998-99, 2001-02, 2005-06, 2006-07
Versus 1981-2010 Longterm Average



Experimental climate divisions – zoom in on CA/NV

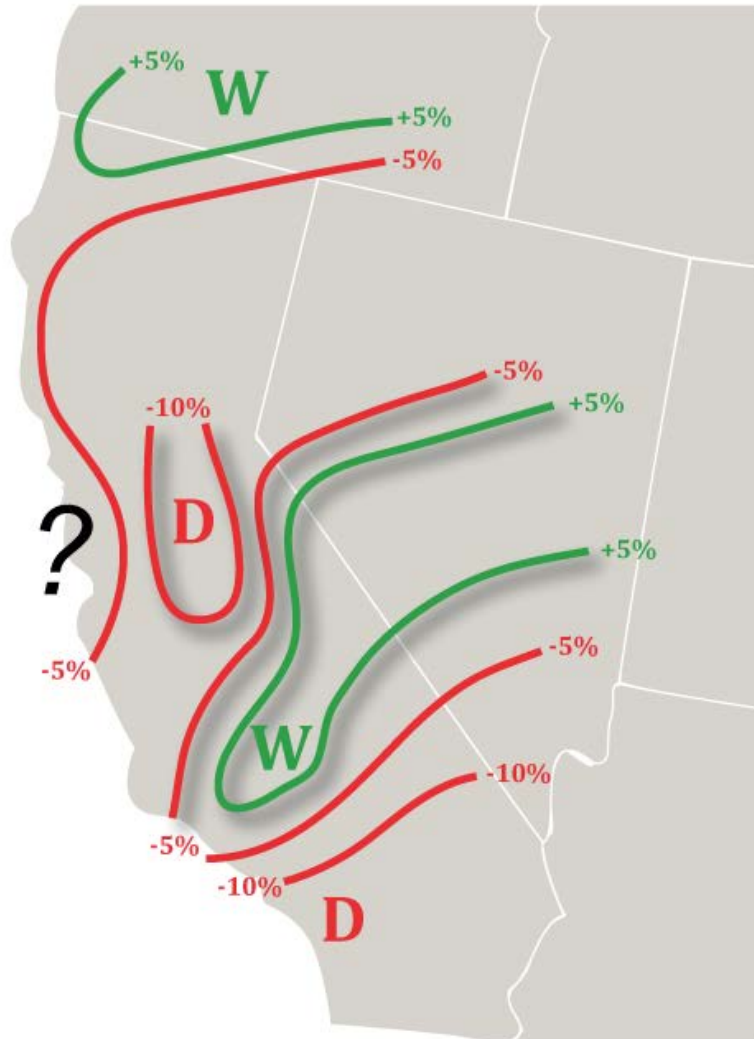


*Amount of color in each station symbol proportional to locally explained variance via core index time series. Seasonal SNOTEL precipitation was correlated against climate division time series and appears to fit well (mainly division “83” (grey)). **These divisions were derived from spatial cluster analysis on seasonal temperature and precipitation data.***

Statistical forecast for this region

Experimental PSD Precipitation Forecast Guidance

DEC '13 – FEB '14 (Issued November 19, 2013)



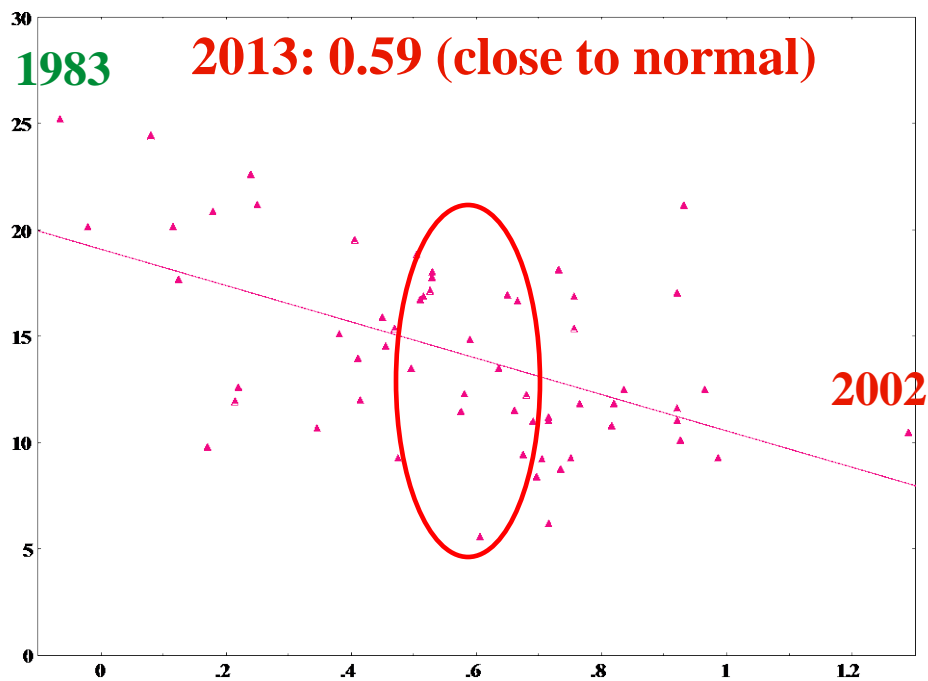
*This map shows the overall shift in the probability distribution for each region – I consider a shift of 10% or more significant, both found on the **dry** side, one over the central valley, and one over southern-most CA. The latter is the region with the highest cross-validated skill overall (along with the northern boundary to OR).*

A question mark denotes inflated tails, i.e., increased variability in the forecast, perhaps a hint at AR-activity?

I will run a spring (MAM) forecast by mid-February 2014.

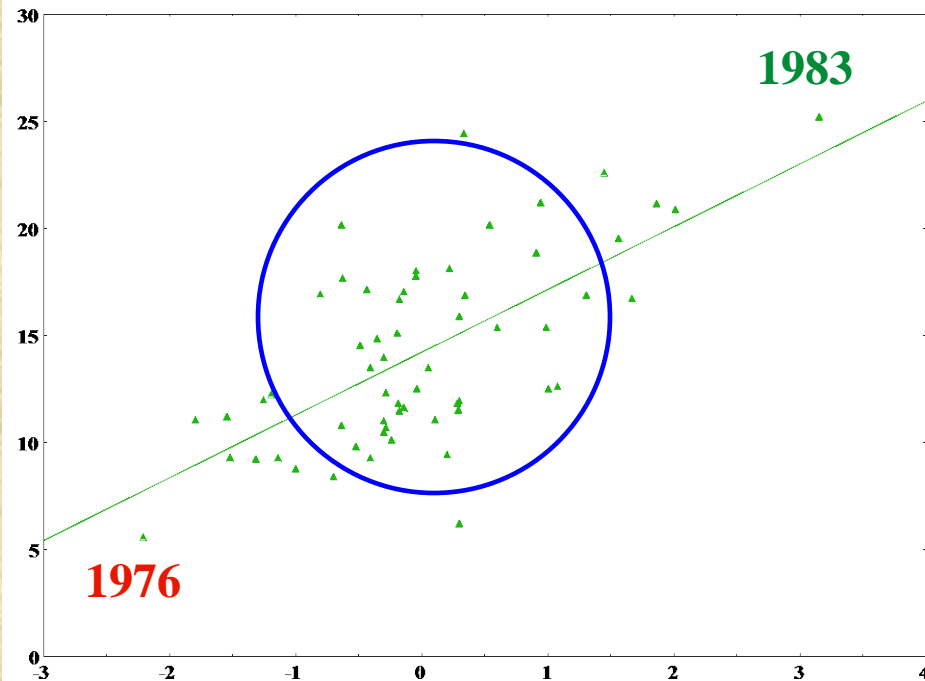
Lees Ferry Naturalized Runoff in Water Year 2014 - Key predictors: *Onset behavior of ENSO (left) + <Oct-Dec>precip (right)*

Lees Ferry [MAf] = $-8.57 \cdot [\text{Niño3-Niño12.July-May}] + 19.1$ <27.8%>



312.67-56

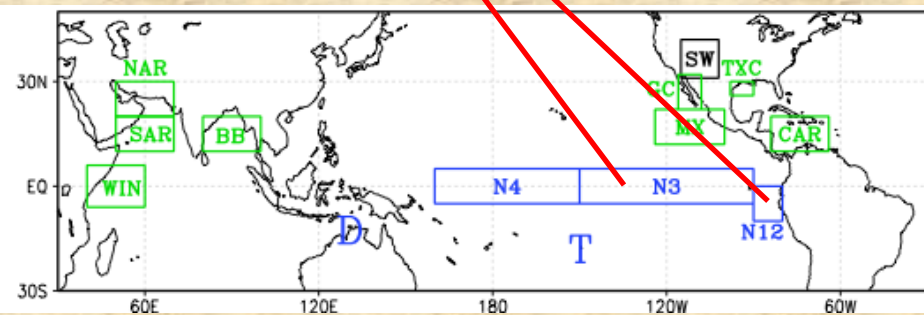
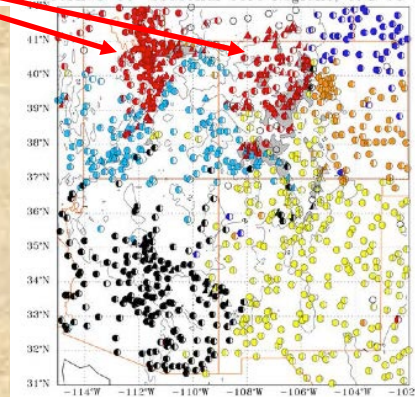
Lees Ferry [MAf] = $2.94 \cdot [\text{Fall precip}] + 14.2$ <42.0%>



ondl

4corn78-99 Seasonal Core Regions, OND 78-99

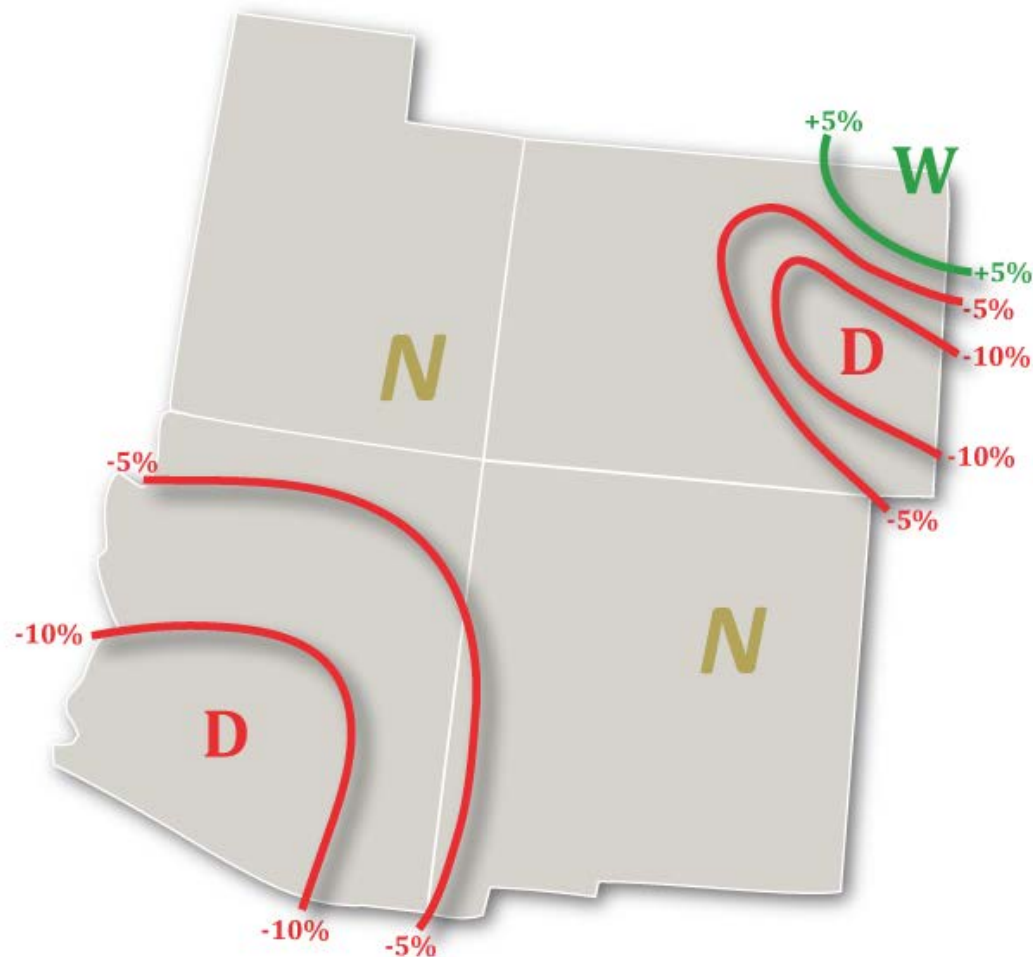
ENSO flavor favors
'normal' runoff (left), while
fall precip in Upper
Colorado Basin is not in
hand yet (right); I lean
towards normal outcome,
also based on mySWE
forecast.



Statistical Forecast for October-December

Experimental PSD Precipitation Forecast Guidance

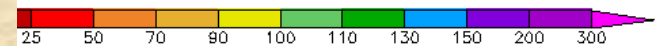
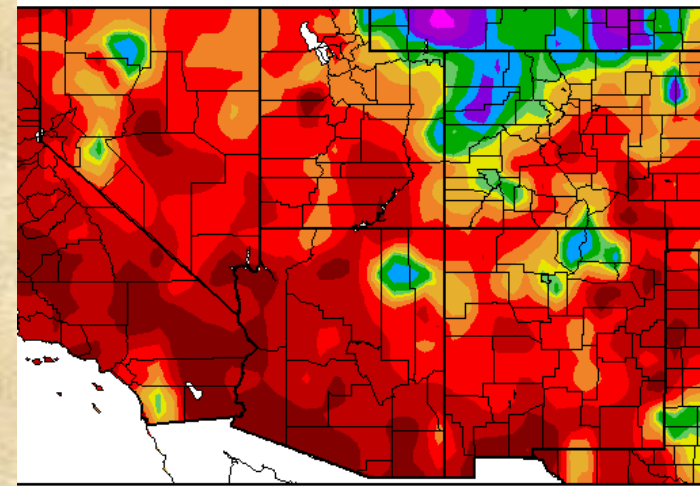
OCT – DEC 2013 (Issued September 11, 2013)



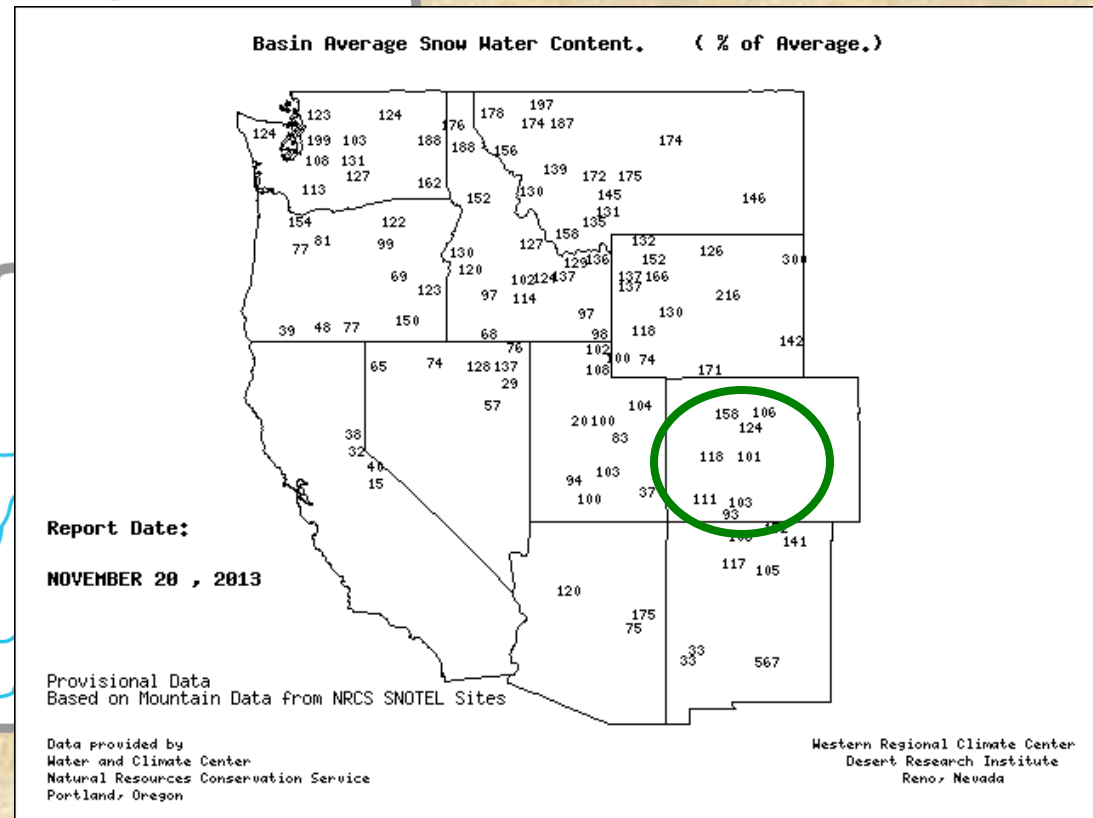
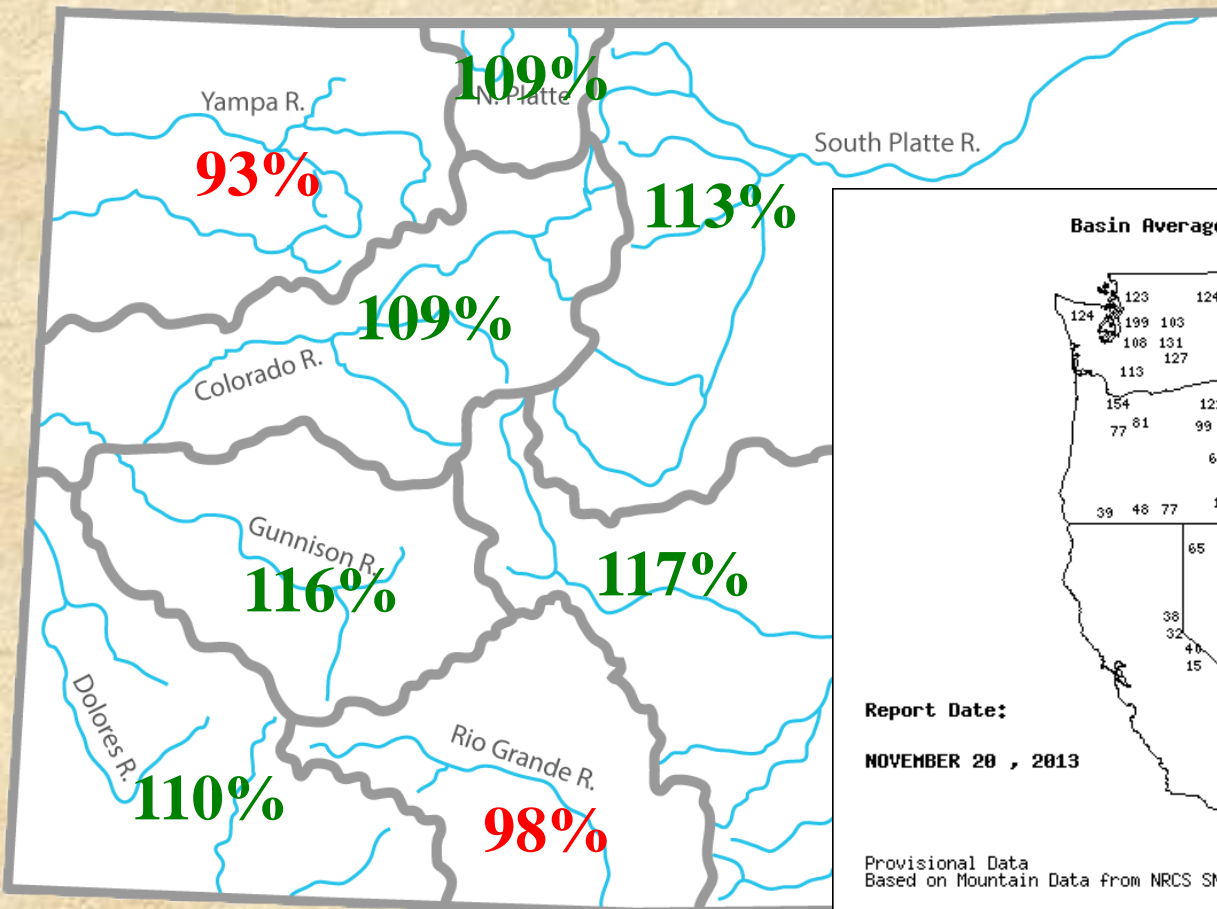
The precipitation forecast for October-December (left) was dry for southeastern Colorado, “wet” in the northeast corner, and climatological for the rest of the state. Historically, my fall forecasts have shown the least skill in the verification period since 1999. So, *caveat emptor!*

So far, not too bad (below):

Percent of Normal Precipitation (%)
10/1/2013 – 11/19/2013



SWE forecast for 1 January 2014 (50%ile)

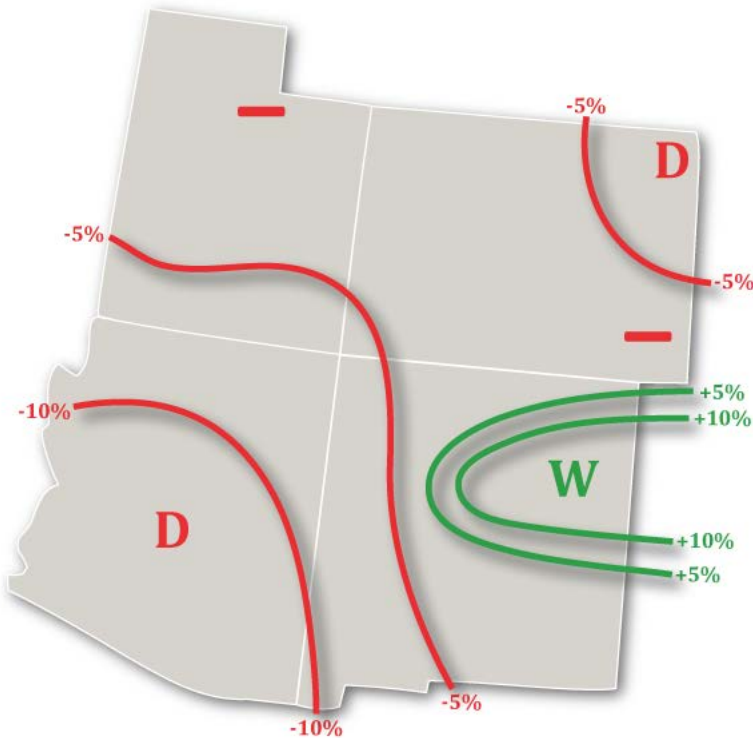


The median forecast for early season snowpack back in September (left) was mostly better than the long-term median in our state, except for the Yampa and Rio Grande basins.

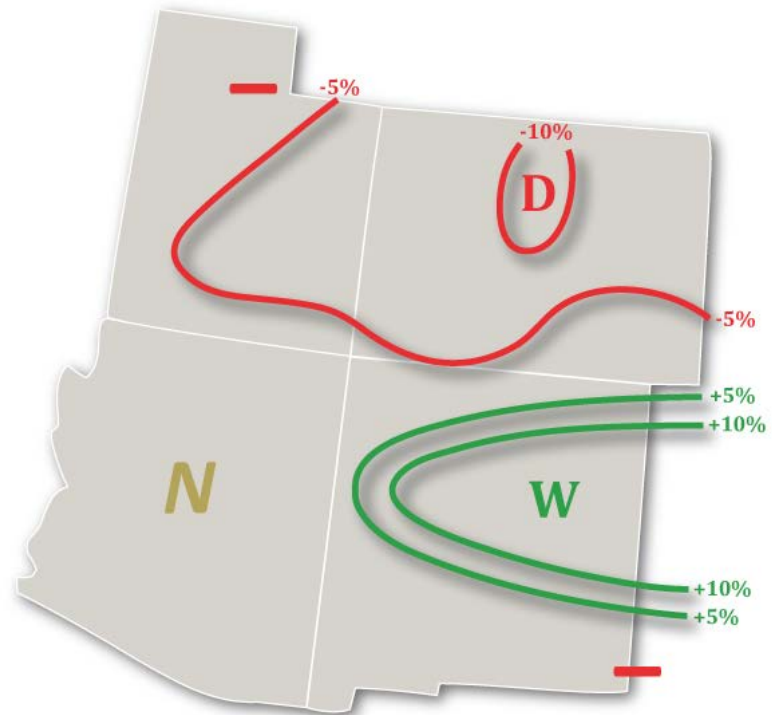
So far, so good (right)!

Statistical Forecast for January-March 2014

Experimental PSD Precipitation Forecast Guidance
JAN – MAR 2014 (Issued September* 2013)

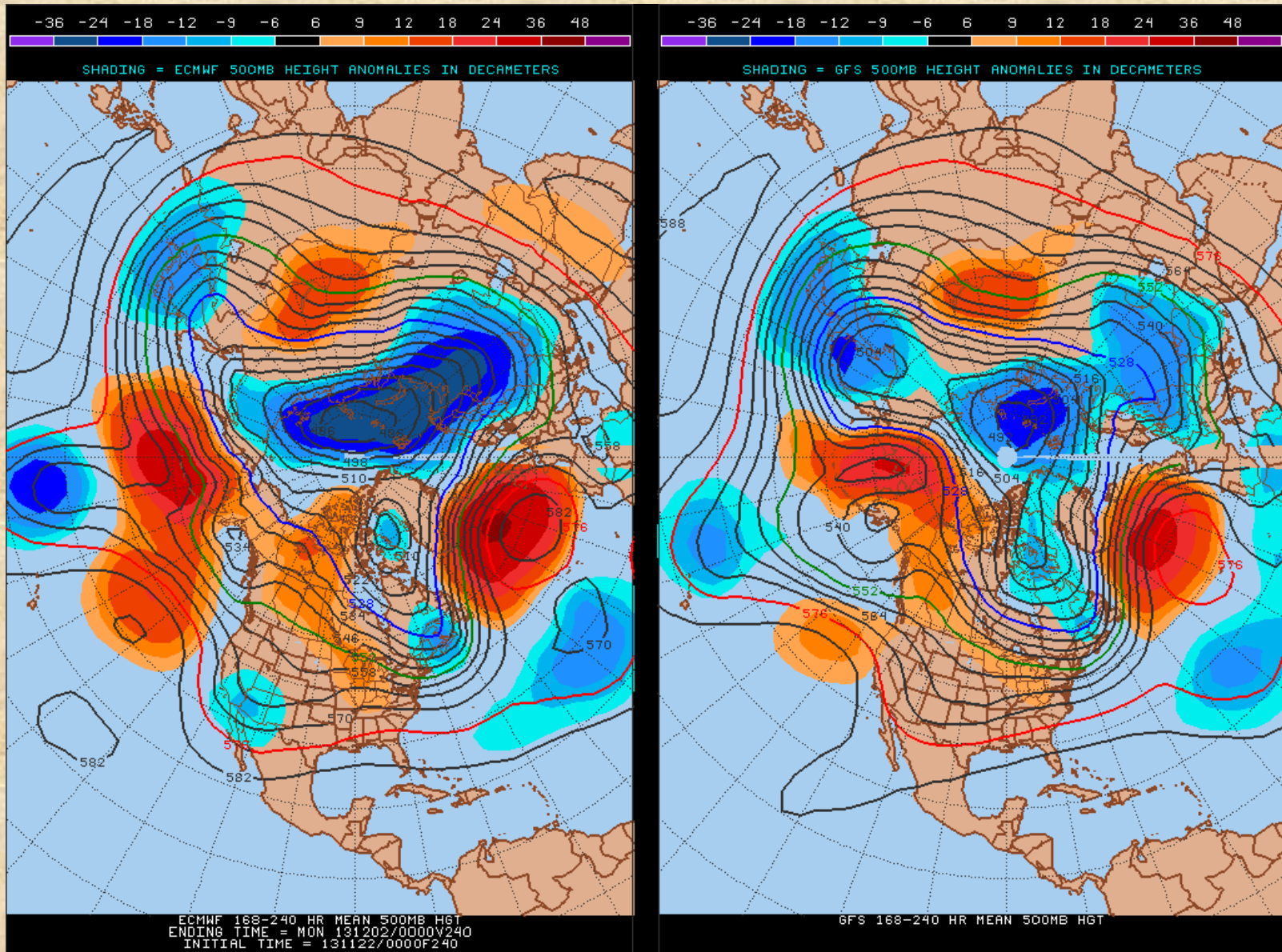


Experimental PSD Precipitation Forecast Guidance
JAN – MAR 2014 (Issued November 13, 2013)



The precipitation forecast for January-March '14 from September initial conditions, but delayed in its calculation (left) was dry for much of the Southwest, neutral over Colorado's mountains, and dry over our eastern plains. The updated forecast (right) is more 'bearish' (dry) for our state, but has actually shown less operational skill since 2000 than the September forecast, so 'not all hope is lost'. *We can't seem to shake "red" forecasts...*

What can we expect towards the end of next week?

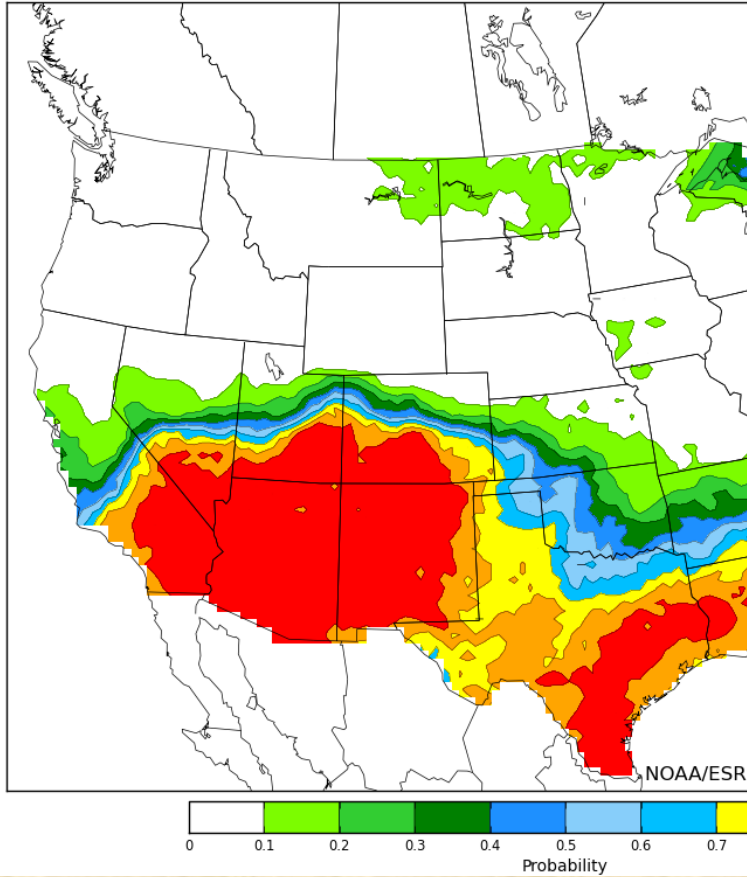


ECMWF (left) gives us split flow over North America, with persistent troughing from southern CA into AZ, while GFS (right) pushes this feature further inland, in effect keeping CA drier.

What can we expect for next two weeks?

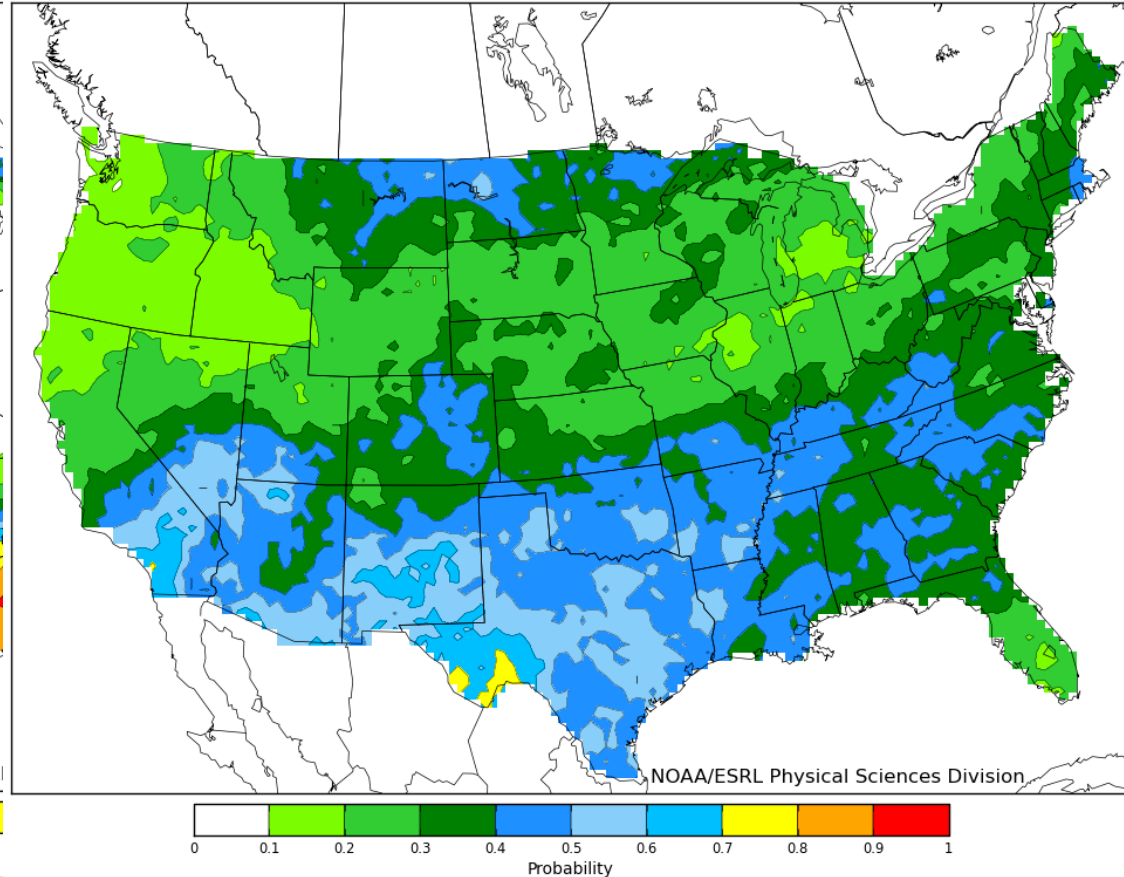
000-168hr fcst from 00Z Fri Nov 22. Valid 00Z Fri 1
Calibrated with 1985-2010 Reforecast2 d

Probability of Precip > 67th Percent



168-336hr fcst from 00Z Fri Nov 22. Valid 00Z Fri Nov 29 - 00Z Fri Dec 06
Calibrated with 1985-2010 Reforecast2 data.

Probability of Precip > 67th Percentile



Reforecast is bullish about the upcoming week (left), and still ahead of 'normal' for Week 2 – in SOUTHERN CA. Looking quite dry for northern CA.

- **Next two weeks appear to favor Southern California, in contrast to the seasonal outlook.**
- **Current classification of positive AMO with negative PDO stacks the odds slightly against southern CA in particular. ENSO-neutral may give way to an El Niño next year, probably too late to change this outlook.**
- **Other influences (Fairbanks warm fall, possible positive NAO this winter, etc.) stack the deck towards a dry winter season in CA. New sea ice influences need to be more thoroughly explored but show a more bullish outlook for southern CA in particular.**
- **My experimental forecast is mostly dry for this region, especially in southern CA, consistent with most other tools.**
- ***Colorado River outlook currently neutral, especially if the basin's current near-normal fall continues.***
- ***Joker in this game: 'Atmospheric River' events***